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THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XL] APRIL 20, 1960 [No. 1

Fragmentary Remains of a Lycopod from the Desmoinesian Series (Pennsylvanian) of Southeastern Kansas

BY

ARTHUR CRIDLAND

ABSTRACT: *Lepidodendron moorei* sp. nov. is described from six specimens found in Kansas coal balls. The assignment of this lycopod to *Lepidodendron* is arbitrary as there are no leaf bases on any of the specimens.

INTRODUCTION

Six coal balls have been collected from southeastern Kansas each of which contain a fragmentary specimen of a distinct fossil lycopod (figures 13-18). The specimens are all considerably crushed and have been invaded by small *Cordaites* roots (*Amyelon radicans* Williamson). Their fragmentary nature is such that if only one specimen was available I would hesitate to describe it as new. As none of the six specimens show any transition to known species of lycopods I believe they are worth describing as a new species. The poor preservation may indicate that these fossils were carried some distance (presumably by water) before preservation. The specimens were studied using the cellulose acetate peel technique described by Joy *et al.* (1956).

Lepidodendron moorei sp. nov.

Holotype specimen: No. 20 in the Kansas University coal ball collection, collected by Dr. R. W. Baxter.

Paratype specimens: No. 826 and No. 831 in the Kansas University coal ball colection, collected by Dr. R. W. Baxter. No. 1078 in the Kansas University coal ball collection, collected by Dr. W. G. Chaloner. No. 1043 in the Henry Shaw School of Botany coal ball collection at Washington University, St. Louis, Missouri, collected by Mr. T. Phillips in July 1958.

Locality and horizon: All of the specimens were collected from the Pittsburg and Midway Coal Company's strip mine north of Hallowell, Cherokee County, Kansas. (Section 4, T. 33 S., R. 22 E.) The coal balls are from the Mineral or Fleming Coal of the Desmoinesian Series. A full classification of these strata is given by Searight *et al.* (1953).

Associated material: In five of the coal balls (Nos. 826, 831, 1020, 1043 and 1078) parts of *Cordaites* are commonest, particularly the leaves. Other fossils present are *Cordaites* stems, *Cordaitanthus* cf. *concinnus* (Delevoryas) Fry, *Cardiocarpus spinatus* Graham, *Alethopteris* sp., *Myeloxylon* sp., *Lepidodendron* leaves, a *Lepidocarpon* cone, a small twig of *Lepidodendron serratum* Felix, *Stipitopteris* cf. *gracilis* Morgan and Delevoryas and fragments of a *Dolerotheca.* In the sixth coal ball (No. 20) the plant remains are mainly *Scolecopteris* and large *Psaronius* roots. Other species present are *Amyelon radicans* Williamson, *Botryopteris* petioles and an undescribed pteridosperm stem.

Diagnosis: Cortex of thick-walled cells, with distinct, parallel, vertical strands of slightly thicker-walled cells. Metaxylem scalariform, bars with a tendency to bifurcate and to become reticulate. No fine vertical striations between the scalariform bars. No corona. No secondary wood. Areas of decay around leaf traces regularly arranged in both vertical and diagonal series.

The species is named after Mr. Kenneth Moore of the Pittsburg and Midway Coal Company through whose co-operation it is possible to collect coal balls at the strip mine north of Hallowell.

Description of the holotype. This specimen is an unbranched crushed stem which is 10 cm. long and 74 mm. x 7 mm. in transverse section. There are 21 strands of thick-walled cortical cells surrounding the exarch siphonostele (fig. 15 and 19). The stem runs into the coal at the edge of the coal ball. In life it was slightly wider than the measurements given and had one to several more strands of thick-walled cells. The strands are mainly isolated from one another but in areas where the preservation is better the strands are joined to each other by intervening slightly thinner-walled cells (fig. 4 and 11). In transverse section the strands are round and about 2.3 mm. in diameter or pear-shaped and about 2.5 mm. x 3.5 mm. (fig. 19). In the outer part of the strands there are localized areas of small cells which grade in size to the surrounding larger cells. These areas of small cells are frequently partly or extensively decayed and the area of decay may extend into the surrounding larger cells. The region occupied by the

smaller cells is about 500 μ across and the cells are polygonal or roundish, 45 μ-60 μ in width. The surrounding larger cells are similar in shape, about 180 μ across, or they may be elongated radially and about 200 μ x 150 μ. In cells least decomposed before fossilization the walls may reach 11 μ in thickness from cell lumen to cell lumen. The cells joining the strands to each other are also thick-walled but their walls are thinner (about 7 μ from cell lumen to cell lumen) than the walls of the cells in the main strands. Many of the cortical cells are poorly preserved. Parts of their walls have separated and at first glance the cell walls appear to be very thick (fig. 21). By comparison with the sequence of cell-wall degradation established by Barghoorn (1952) I presume that these are remnants of the outer part of the secondary wall and a dark residue between them is all that remains of the inner layers of the secondary wall and the primary wall. Tangential sections show that the strands of cortical cells are parallel and in areas of better preservation thinner-walled cells join the strands to each other (fig. 4). The tangential sections were cut obliquely and although the length of the thick-walled cortical cells could not be measured accurately they are more than 900 μ long.

The exarch siphonostele is 7 mm. x 1.2 mm. from protoxylem to protoxylem and is composed entirely of tracheids. There is no definite corona but there are occasionally very small groups of protoxylem cells projecting from the main protoxylem of the stele (figure 2). These groups of cells are few, poorly preserved and have no regular arrangement. The main part of the protoxylem forms a narrow zone at the periphery of the siphonostele. In transverse section the cells of the protoxylem are 30 μ in diameter and the metaxylem tracheids are 120 μ radially x 75 μ tangentially. The walls of the tracheids are well preserved and have not decomposed like those of the cortical cells. (The detailed structure of the tracheids is the same as in specimen No. 831 where the stele is described in greatest detail). No leaf traces are to be seen leaving the stele. There is no secondary wood.

Description of the paratypes. Specimen No. 831. This specimen is similar to No. 20 but it is smaller. The specimen lies near the edge of the coal ball and as a result part is missing. The part preserved is a little more than 5 cm. long and is 19 mm. x 4.5 mm. in transverse section. There are twenty strands of thick-walled cortical cells still present around the stele (fig. 5 and 17). In transverse section these strands are rounded (about 1.2 mm. in diameter) to ovoid (about 1.3 mm. x 1.0 mm.). The cells joining the strands

to each other are not well preserved in this specimen. The thick-walled cells of the strands are similar in shape and preservation to those in specimen No. 20. They are from 48 μ-120 μ in diameter or else they are elongated radially and about 120 μ x 80 μ. There is no localized region of small cells in the cortical strands as there is in specimen No. 20. Specimen 826 is the only other specimen lacking this localization of smaller cells in the cortical strands.

In transverse section the stele is 6 mm. x 1 mm. from protoxylem to protoxylem. There are small projections from the main protoxylem of the stele as in specimen No. 20 but they are not numerous and not conspicuous enough to form a corona. The metaxylem tracheids measure 130 μ radially x 67 μ tangentially in transverse section and they have scalariform thickening on the radial and tangential walls. The scalariform bars often bifurcate (fig. 8) and frequently fairly robust vertical or almost vertical bars develop and connect the scalariform bars giving a reticulate appearance (fig. 3). There are none of the fine vertical striations between the scalariform bars which have been observed in so many fossil lycopods (see Barghoorn and Scott, 1958). The scalariform bars of the metaxylem tracheids are about 5 μ in diameter and there is a distance of about 10 μ between the bars. The length of the tracheids was not determined. The protoxylem consists of tracheids which are about 30 μ in diameter and have spiral or annular thickening (fig. 20). The thickenings are about 2.5 μ in diameter.

Specimen No. 826. This specimen is similar to specimen No. 831 but here the whole width of the stem is preserved. It is about 9 cm. long and 28 mm. x 3.2 mm. in transverse section. There are 25 strands of thick-walled cortical cells around the siphonostele (figs. 7 and 13). These strands are 1.5 mm. to 2 mm. in diameter. Tangential sections show that some slightly thinner-walled cells are present joining the strands to each other (fig. 6) but they are not abundant. The tangential sections prepared were oblique and although the length of the thick-walled cortical cells could not be measured accurately, they are more than 1 mm. long.

The crushed stele is 6 mm. x 1 mm. from protoxylem to protoxylem. Both the metaxylem and the protoxylem are similar to that described in specimen No. 831.

Specimen No. 1078. This specimen is at least 5 cm. long (only one half of the coal ball was available for study) and 40 mm. x 8 mm. in transverse section. Twenty strands of thick-walled cortical cells are preserved around the siphonostele (fig. 14). The strands of

thick-walled cells are similar to those described in specimen No. 20. Many of the cells joining the strands to each other are preserved (fig. 10).

The stele is 6 mm. x 1 mm. from protoxylem to protoxylem in transverse section and is of the same structure as those in the previously described specimens.

Transverse sections of this specimen show a zone of thin-walled cells outside the strands of thick-walled cortical cells (fig. 10). This zone is poorly preserved but in several places it is clear that these cells are joined to the thick-walled cells of the strands (fig. 1). These thin-walled cells are squarish to irregular and about 110 μ across. Radial sections show that this thin-walled tissue is considerably broken.

Specimen No. 1020. This specimen is 11 cm. long and 72 mm. x 7.5 mm. in transverse section. It is heavily pyritized. Transverse sections show 22 strands of thick-walled cells similar to those in specimens No. 20 and No. 1078. These strands are completely joined to each other by intervening cells (figs. 12 and 18). Tangential sections of the cortex show that it has gaps in the tissue between the strands (fig. 23). These gaps are arranged in regular vertical and diagonal series. They occasionally contain fragments of tracheids having scalariform thickening which are interpreted as the remains of leaf traces. The gaps in the cortex represent areas of decay around them. The tracheids in these leaf traces are not well preserved but scalariform bars can be seen. The leaf traces could not be followed back to the stele which is very poorly preserved.

The approximate size and position of the stele is indicated in fig. 12. The few cells preserved show that it was an exarch siphonostele. The metaxylem tracheids are about 100 μ radially x 75 μ tangentially in transverse section. As the stele is badly decomposed it is not possible to say whether these were the largest tracheids in the stele. Scalariform thickenings were seen on the radial and tangential walls of the metaxylem tracheids.

Specimen No. 1043. This specimen is in a pyritized coal ball. It is of interest because leaf traces are preserved. The specimen is about 12 cm. long and 37 mm. x 7 mm. in transverse section. There are 31 strands of thick-walled cells surrounding the siphonostele (figs. 9 and 16). This number is approximate because all of the strands are not completely isolated from each other. The strands of thick-walled cells are ovoid and are 3 mm. radially x 1.8 mm. tan-

gentially in transverse section. The individual cells are about 100 μ in diameter to 156 μ radially x 108 μ tangentially. As in the other specimens the cells of the cortical strands are considerably decomposed (fig. 24). In tangential sections the parallel nature of the strands can be seen very clearly (fig. 22). The individual cells are more than 800 μ long. The strands are joined into a cylinder by intervening cells which are very well preserved in this specimen. Large, regularly arranged gaps are present in the tissue between the strands and most of these gaps have a leaf trace at one end (fig. 25). The leaf traces in these gaps are not well preserved and are usually cut obliquely. Scalariform thickening can be seen on the tracheid walls and in some cases fine vertical striations are present between the scalariform bars but these are not very distinct. Where the leaf traces in these gaps have been cut transversely they are semicircular and are about 500 μ deep and 900 μ wide. The individual cells which are preserved are squarish and 180 μ across. The cells near the center of the traces are poorly preserved but there is a suggestion that the leaf traces are mesarch.

The stele itself is much broken but is clearly exarch. The estimated measurement before fragmentation is 9 mm. x 1.2 mm. from protoxylem to protoxylem. The metaxylem is composed of radially elongated cells which are 120 μ x 62 μ. The protoxylem is also elongated radially and the individual cells are 58 μ x 38 μ. Unfortunately the stele is surrounded by pyrite and although the preservation of the outer regions is better than in the other specimens it is still not as good as one desires. There are projections from the outer edge of the stele. These are all interpreted as leaf traces. Before the leaf traces separate from the stele they are elongated tangentially and are 144 μ x 72 μ (fig. 24). When they are completely detached from the stele they are similar in shape but slightly longer in the tangentially direction (160 μ x 70 μ). There are no obvious pointed projections from the stele which could be interpreted as parts of a typical lycopod corona. The metaxylem tracheids of the stele have scalariform thickening on the radial and tangential walls and the scalariform bars occasionally bifurcate. There are no fine vertical striations between the scalariform bars. The protoxylem tracheids have spiral or annular thickening. There is no secondary wood.

DISCUSSION

The crushed stems vary in size considerably (figs. 5, 7 and 9-12). The smallest specimen is 28 mm. x 3.2 mm. in transverse section while the largest is 72 mm. x 7.5 mm. in transverse section. The

stele is less variable in size and ranges from 6 mm. x 1 mm. to 9 mm. x 1.2 mm. in transverse section. The general arrangement and appearance of the tissues is the same in all the specimens and it is safe to assume that they all belong to the same species.

The exarch siphonostele composed entirely of tracheids and the scalariform thickening of the metaxylem suggest that the fossils described here are lycopod stems. This is supported by specimens No. 1020 and No. 1043 in which there is evidence that they bore closely set leaf bases which were regularly arranged both in vertical and diagonal series (figs. 22 and 23). The outer edge of the stele does not show a corona, a structure which is characteristic of known petrified lycopods, but its absence may be a result of poor preservation. Very small, irregularly arranged projections from the protoxylem of the stele in some specimens suggest that a corona could have been present. No fine vertical striations are to be observed between the scalariform bars of the metaxylem even under examination with an oil-immersion objective. In some of the leaf traces seen in specimen No. 1043 there are a few striations but they are not as abundant as they appear even in poorly preserved specimens of other fossil lycopods. There is no secondary thickening even in the largest specimens.

The absence of leaf bases makes it impossible to determine to which genus of lycopods the species belongs. The arrangement of the leaf traces in vertical as well as diagonal series (in contrast to an arrangement in diagonal series only) is commonest in the genus *Sigillaria* but is also found in *Lepidodendron volkmanianum* Sternberg. Rather than definitely assigning these fossils to *Sigillaria* without knowing the characters of the leaf cushions I have followed Arnold (1940) for *Lepidodendron johnsonii* and Felix (1952) for *Lepidodendron kansanum* in assigning fossil lycopods without leaf bases to the genus *Lepidodendron*.

Several comparisons can be made with previously described species of *Lepidodendron*. The figures of *L. vasculare* Binney in Leclercq (1925) are instructive. In Leclercq's plate 16 the middle cortex of the specimen has broken down into islands of cells similar to the strands of thick-walled cells in *L. moorei*. This is significant as it shows that similar decomposition of the cortex has been recorded in at least one other fossil lycopod. There is no evidence to refer the specimens described here to *L. vasculare*.

Of the lycopods described by Felix (1952) from southeastern Kansas closest comparison can be made with *Lepidodendron dicentricum*. This has a middle cortex which looks similar to the

strands of thick-walled cells of *L. moorei.* In *L. dicentricum* the primary stele is wider than in *L. moorei.* Also similar-sized specimens show that whereas there is considerable secondary thickening in *L. dicentricum* there is none in *L. moorei.* Furthermore *L. dicentricum* has its primary xylem divided into an inner and an outer region. Nothing comparable to this has been observed in *L. moorei.*

Lepidodendron serratum Felix from the same locality is a siphonostelic form which like *L. moorei* has no secondary wood. There is nothing in the structure of *L. serratum* to suggest that on decomposition strands of thick-walled cells similar to those in *L. moorei* will be formed. The leaf cushions in *L. serratum* cannot be arranged in a vertical series as well as a diagonal series and its metaxylem tracheids are larger in transverse section than those of in *L. moorei.*

ACKNOWLEDGMENTS

I wish to express my thanks to Dr. R. W. Baxter for his helpful advice and criticism during this work.

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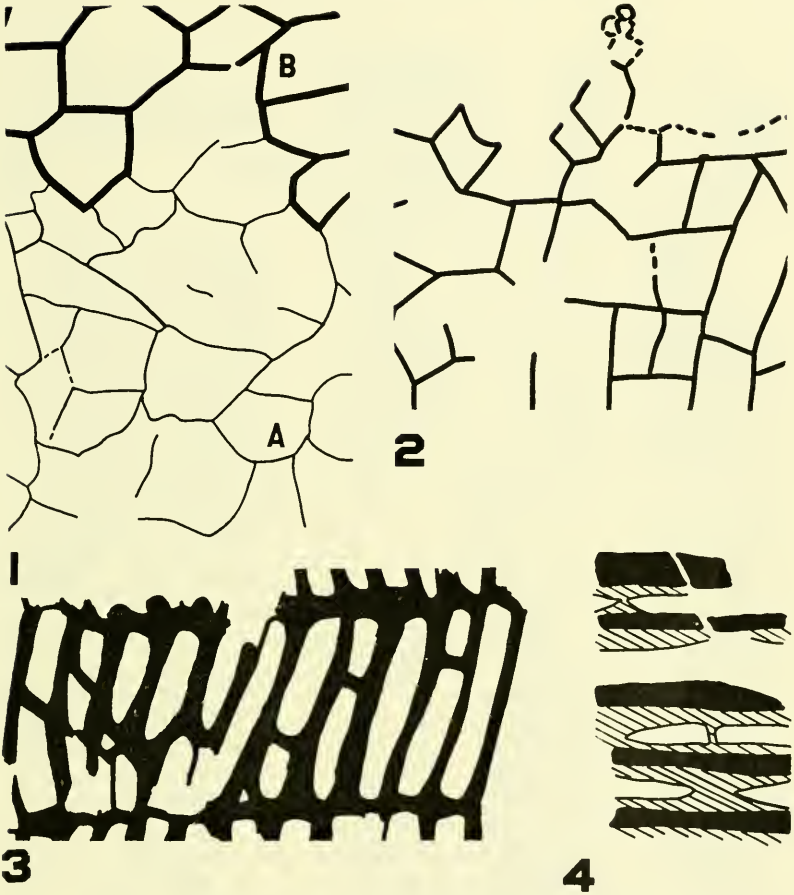


FIGS. 1-4. *Lepidodendron moorei* sp. nov.

Fig. 1. Transverse section of specimen No. 1078 showing part of the thin-walled cortex (A) joined to a thick-walled cortical strand (B). Slide No. 213, × 100.

Fig. 2. Transverse section of the outer edge of the stele of specimen No. 20, showing a small protoxylem projection at the top of the figure. Slide 201, × 400.

Fig. 3. Part of a metaxylem tracheid showing the tendency for the scalariform bars to become reticulate. Radial section of specimen No. 831. Slide No. 207, × 400 (mounted sideways).

Fig. 4. Tangential section of specimen No. 20 showing the vertical strands of thick-walled cortical cells. Some of the cells joining the strands to each other are still present (shown by diagonal lines). Slide No. 206, × 2 (mounted sideways).

Fig. 5. Transverse section of specimen No. 831 showing 20 strands of thick-walled cortical cells around the siphonostele. Slide No. 208, × 2.

Fig. 6. Tangential section of specimen No. 826 showing the vertical strands of thick-walled cortical cells. The small amount of tissue joining the strands to each other is shown by diagonal lines. Slide No. 211, × 2.

Fig. 7. Transverse section of specimen No. 826 showing 25 strands of thick-walled cortical cells around the siphonostele. Slide No. 210, × 2.

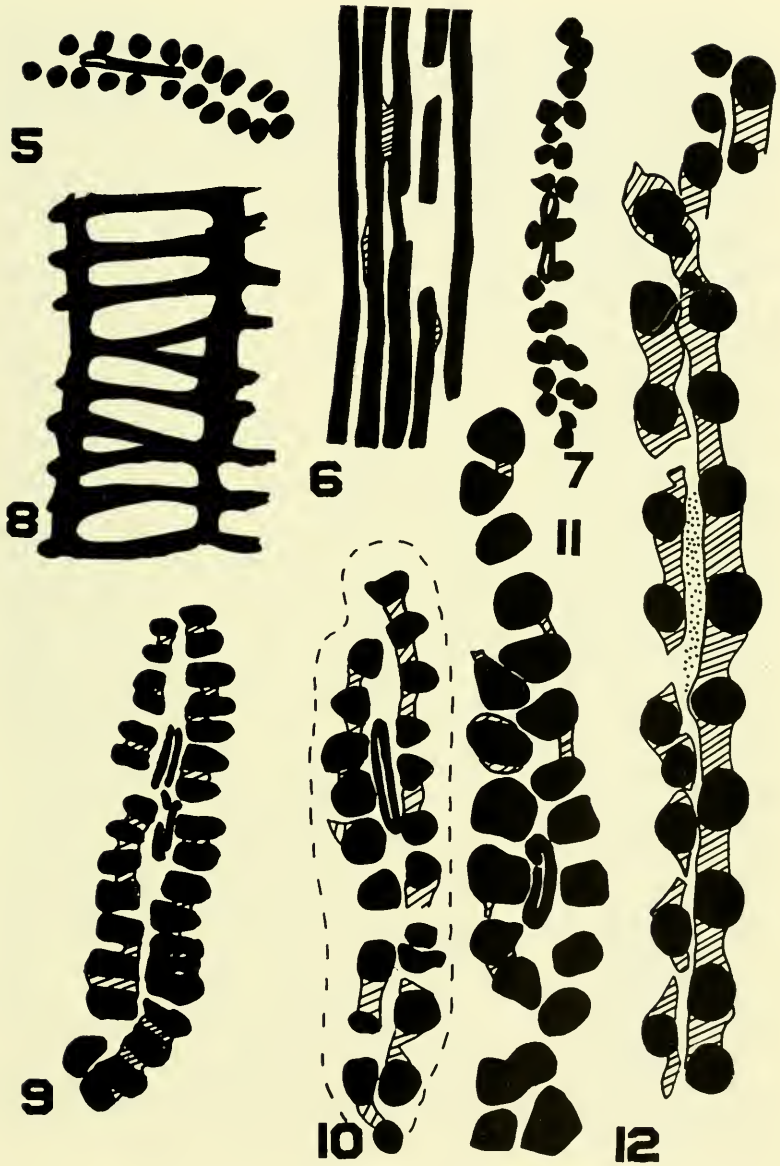
Fig. 8. Part of a tracheid from specimen No. 831 in tangential section. Two of the scalariform bars show bifurcations. Slide No. 209, × 400.

Fig. 9. Transverse section of specimen No. 1043 showing 32 strands of thick-walled cortical cells around a broken siphonostele. The tissue joining the strands to each other is shown by diagonal lines. Slide 291, × 2.

Fig. 10. Transverse section of specimen No. 1078 showing 21 strands of thick-walled cortical cells around the siphonostele. The tissue joining the strands to each other is shown by diagonal lines. The broken line represents the limit of a thin-walled cortical tissue outside the strands of thick-walled cells.

Fig. 11. Transverse section of specimen No. 20 showing 20 strands of thick-walled cortical cells surrounding the siphonostele. The small amount of tissue joining the strands to each other is shown by diagonal lines. Slide No. 201, × 2.

Fig. 12. Transverse section of specimen No. 1020 showing 24 strands of thick-walled cortical cells and a large amount of tissue joining the strands to each other (shown by diagonal lines). The position of the poorly preserved stele is shown by stippling. Slide No. 202, × 2.



FIGS. 5-12. *Lepidodendron moorei* sp. nov.

Figs. 13-18. *Lepidodendron moorei* sp. nov. Transverse sections of the six specimens showing the arrangement of the strands of thick-walled cells around the stele.

Fig. 13. Specimen No. 826. Slide No. 210, × 3.

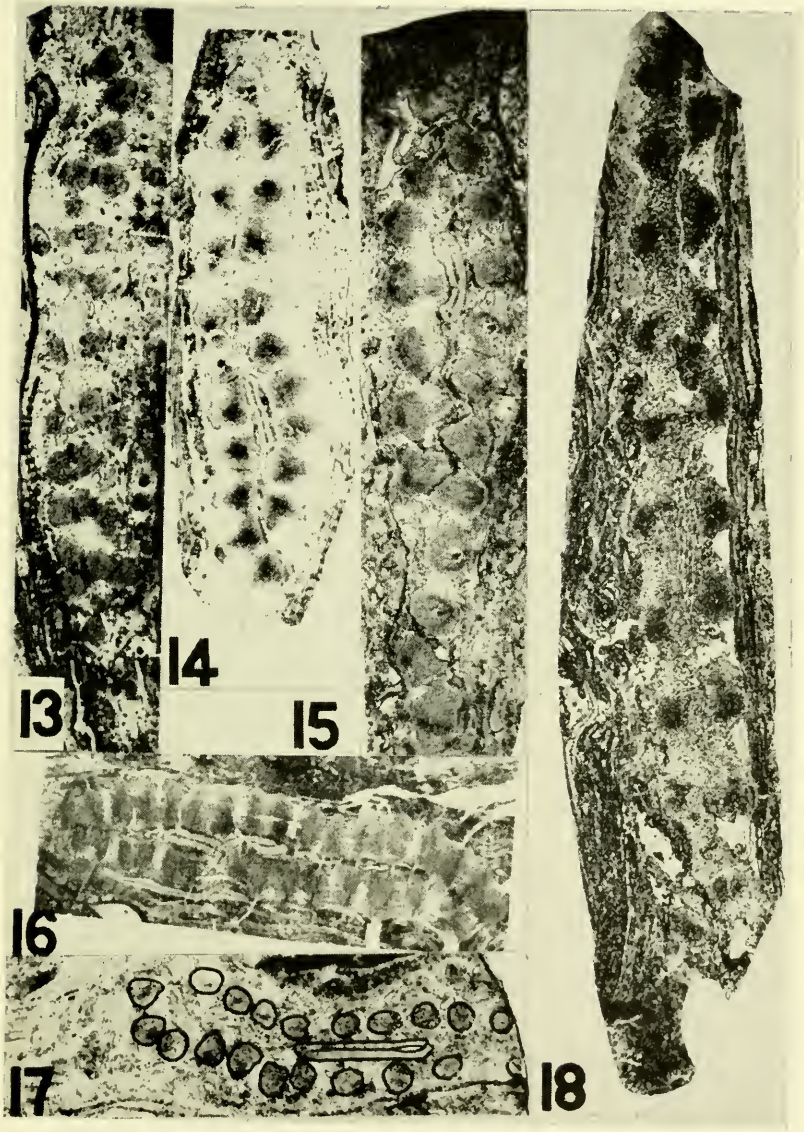
Fig. 14. Specimen No. 1078. Slide No. 220, × 2.

Fig. 15. Specimen No. 20. Slide No. 201, × 2.

Fig. 16. Specimen No. 1043. Slide No. 291, × 2.

Fig. 17. Specimen No. 831. This photograph has been retouched to show the position of the stele and the cortical strands. Slide No. 208, × 3.

Fig. 18. Specimen No. 1020. The stele is very poorly preserved in this specimen. Slide No. 222, × 2.

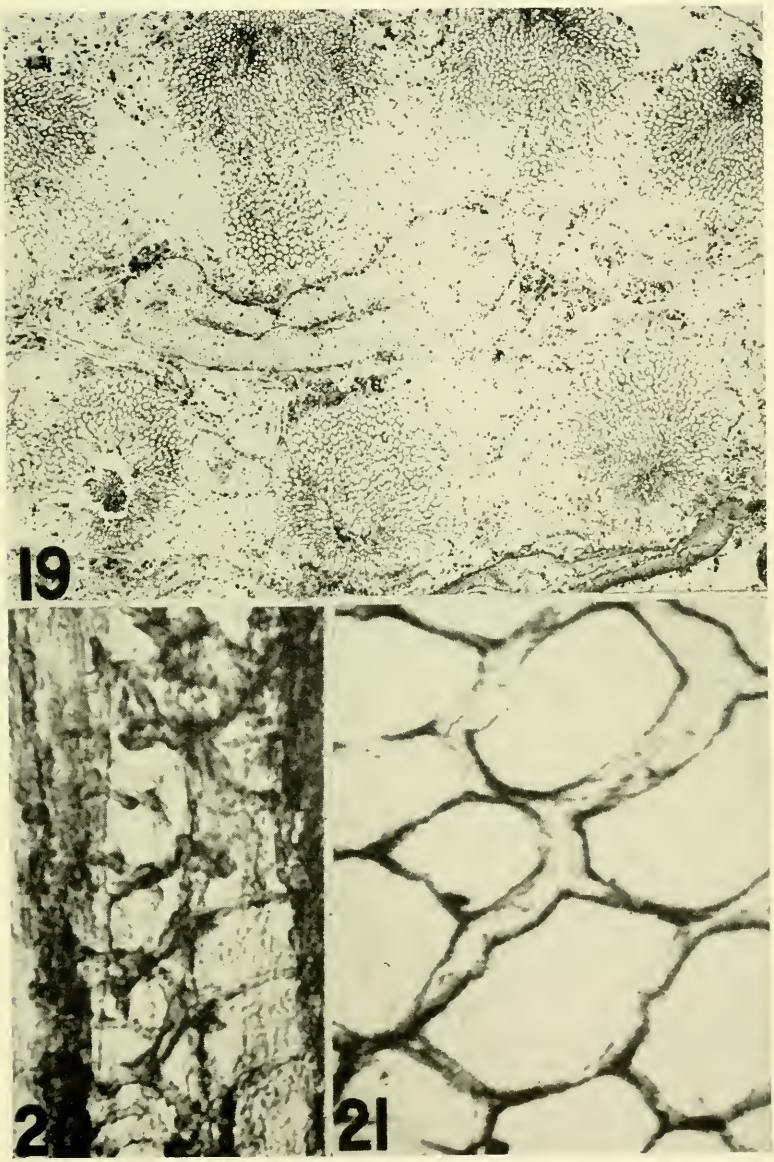


FIGS. 13-18. *Lepidodendron moorei* sp. nov.

Fig. 19. Transverse section of specimen No. 20 showing the stele and surrounding strands of thick-walled cortical cells. Localized areas of small cells can be seen in the two strands to the right-hand side of the figure. Slide No. 201, × 8.

Fig. 20. Oblique tangential section through the protoxylem of specimen No. 831 showing the spiral and annular thickening of the tracheids. Slide No. 209, × 500.

Fig. 21. Transverse section of the partly decomposed thick-walled cortical cells of specimen No. 20. Slide No. 201, × 200.



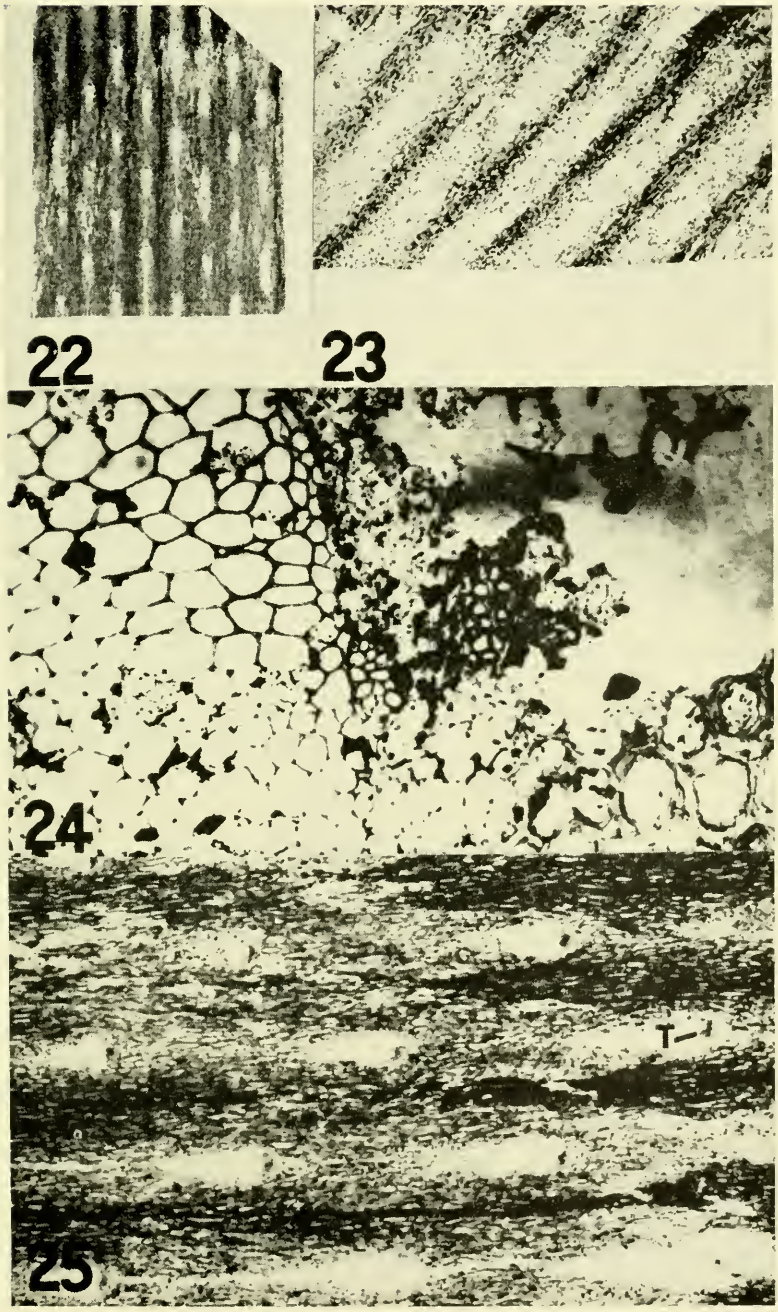
FIGS. 19-21. *Lepidodendron moorei* sp. nov.

Fig. 22. Tangential section of the cortex of specimen No. 1043 showing the parallel strands of thick-walled cortical cells which are joined to each other by a slightly thinner-walled tissue. This thinner-walled tissue has regularly arranged gaps. Slide No. 279, × 2.

Fig. 23. Tangential section of the cortex of specimen No. 1020 showing the parallel strands of thick-walled cells which are joined to each other by a slightly thinner-walled tissue. This thinner-walled tissue has regularly arranged gaps. The photograph is mounted obliquely. Slide No. 230, × 2.

Fig. 24. Transverse section of specimen No. 1043. The left-hand side of the photograph shows the outer edge of the exarch siphonostele with a leaf trace which is not yet detached. To the right of this there is a leaf trace which is completely detached from the stele and is traversing the cortex. The lower right-hand corner of the photograph shows some partly decomposed cells belonging to one of the strands of thick-walled cortical cells. Slide No. 263, × 100.

Fig. 25. An enlarged portion of the specimen shown in figure 22 showing a leaf trace (T) at the upper edge of each of the gaps. The photograph is mounted on its side so that the upper edges of the gaps are at the right. Slide No. 279, × 5.



FIGS. 22-25. *Lepidodendron moorei* sp. nov.

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A New Softshell Turtle (Genus Trionyx) from Coahuila, Mexico

BY

ROBERT G. WEBB and JOHN M. LEGLER

For ten days in September, 1958, a field party from the University of Kansas Museum of Natural History (KU) collected aquatic vertebrates in central Coahuila, Mexico. Among the specimens are 14 examples of *Trionyx* obtained in the basin of Cuatro Ciénegas. Examination of these turtles revealed the presence of two distinct species. Five of the specimens are *Trionyx spinifer emoryi.* The remaining nine specimens and one other individual, in the University of Illinois Museum of Natural History (IU), represent a previously unrecognized species that, in allusion to its over-all blackish coloration, may be known as:

*Trionyx ater** sp. nov.

Black Softshell

?*Amyda mutica*, Müller, Verh. Naturf. Ges. Basel, vol. 6, 1878, p. 641.

Holotype.—KU 46903, alcoholic; female; obtained 16 kilometers south of Cuatro Ciénegas, Coahuila, September 6, 1958, by John M. Legler, Wendell L. Minckley, and Robert B. Wimmer; original number, JML 1708 (Pl. I).

Paratypes.—A total of nine alcoholic specimens: KU 46904-6, 46908-10, 46912 (females), KU 46911 (male); same data as holotype; obtained September 6 to 8, 1958; IU 43510 (female), obtained 5.7 miles west of Cuatro Ciénegas, Coahuila, July 10, 1958, by Pete S. Chrapliwy and Kenneth L. Williams.

Diagnosis.—A species of softshell turtle most closely allied to *Trionyx spinifer emoryi* and having: (1) uniform blackish colora-

* ater (Latin) = black.

tion (rather than a pattern of pale and dark markings) on the carapace and dorsal surfaces of limbs, neck, and head; (2) ventral surfaces heavily speckled with black; (3) no evidence of a pale marginal band on carapace (females only); (4) longitudinal corrugations on the posterior part of the carapace (most females); (5) no ridges projecting into the nostrils (septal ridges) from the nasal septum in males; (6) small white tubercles on posterior half of carapace (males only); and (7) an ovoid carapace (adult and nearly adult specimens).

Description of holotype.—Carapace ovoid, margin smooth laterally, rugose posteriorly; dorsal surface of carapace smooth except for posterior part; anterior margin of carapace having obtuse prominences but lacking tubercles; posterior fleshy part of carapace having numerous minute longitudinal corrugations; width of carapace contained in length, 1.4 times; height contained in width, 2.8 times. Posterior lobe of plastron rounded and truncate; width of bony bridge, 32 millimeters. Head terminating in elongate fleshy snout; nostrils rounded, each with a ridge (septal ridge) projecting laterally from nasal septum; horny parts of jaws concealed by fleshy lips except anteriorly; internal nares each partly covered by elongate flap of oral integument projecting from lateral border, each flap bearing fleshy denticulations on medial edge; least distance between orbits, 4 millimeters. Forefeet and hind feet fully webbed, having five digits each; first three digits of each foot bearing claws; four cornified areas (three of which are falciform and have a free edge) on antebrachium; each hind limb having smooth cornified area on posterodorsal surface and another (with free edge) on posteroventral surface. Tip of tail flexible, blunt, projecting beyond posterior edge of carapace; skin of tail rugous, less so ventrally than dorsally; anterior tip of cloaca to tip of tail, 20 millimeters; posterior edge of carapace to tip of tail, 24 millimeters (see table 1 for other measurements of holotype and paratypes).

Dorsal surface of carapace blackish in general aspect (dense mottling of blackish brown and gray evident when specimen is immersed in preservative), lacking pale marginal band; plastron and undersurfaces of carapace whitish, having numerous small blackish marks; blackish marks more numerous in area of bridge than on other ventral surfaces; hyoplastra, hypoplastra, and xiphyplastra (plastral callosities) bluish gray where visible beneath translucent skin of plastron; snout and side of head bluish gray; head and neck blackish above, bluish white with fine scattered darker markings below; no pattern on snout or side of head; limbs slate with paler

areas of bluish gray above, whitish and tinged with red below; ventral surfaces of hind feet speckled with black; inguinal area whitish, tinged with red, lacking darker markings; tail slate above, whitish and tinged with red below.

Variation.—The paratypic series consists of one adult male (mature, as indicated by elongate preanal region with cloaca extending beyond posterior edge of carapace, and fully developed penis) and eight subadult females.

The male (Pl. II) is unique in lacking septal ridges. The carapace is dark gray and has small white tubercles posteriorly. The anterior edge of the carapace is smooth. The posterior edge of the carapace has an obscure pale narrow band, and lacks the corrugations seen in females. The over-all dorsal coloration is blackish. The ventral surface is whitish with a few black marks on the underside of the posterior flap of the carapace. The ventral surfaces of the tail and hind limbs are tinged with red.

The seven females resemble the holotype in over-all blackish dorsal coloration, obtuse prominences on the anterior edge of the carapace, and lack of a pale band on the posterior edge of the carapace. Shape of carapace varies from ovoid (KU 46908) to nearly circular (KU 46909). Four of the specimens (KU 46904, 46908, 46910, and 46912) differ from the holotype in lacking longitudinal corrugations on the posterior part of the carapace. On the smallest female (KU 46904) a dark line extends anteriorly from each eye and a dark line connects the anterior margins of the orbits. Black pigment on the ventral surfaces is reduced in three specimens (KU 46904, 46910, and 46912). The ventral surface of the tail is especially reddish in two specimens (KU 46910 and 46912).

Flaps of skin extending from the lateral borders of the internal nares partly cover the nares of all KU paratypes as well as the holotype. Flaps occur also in the specimens of *T. spinifer emoryi* examined by us (as well as in other forms of *Trionyx* examined by Webb); the flaps in *emoryi* differ from those of *ater* chiefly in being folded vertically against the lateral borders of the nares (not extending horizontally into and partly covering the nares). Possibly the flaps are movable; as yet, we are unable to evaluate the functional and taxonomic significance of these flaps.

One female paratype (IU 43510) more closely resembles *T. spinifer emoryi* than do other specimens of *T. ater.* Pertinent features of the paratype are as follows: (1) more prominent mottling of carapace and other dorsal surfaces; (2) posterior rim of carapace having obscure, pale, narrow band; (3) snout having obscure,

emoryi-like pattern of dark lines; (4) plastron less extensively blackish; and (5) internal narial flaps vertical, not projecting into internal narial openings. Possibly the specimen is a hybrid.

Range.—Known only from the type locality and other ponds in the basin of Cuatro Ciénegas, central Coahuila, Mexico. Müller (1878:641) listed *Amyda mutica* from "Mexico" but did not mention a specific locality. Presumably Müller referred to a male of *T. ater* (*T. muticus* is not known to occur in Mexico). The present report brings to two (*T. ater* and *T. spinifer emoryi*) the number of kinds of softshell turtles known to occur in Mexico.

Relationships.—*Trionyx ater* can be distinguished from all other American forms of the genus by the following combination of characters: (1) an over-all blackish, dorsal coloration; (2) lack of all but a trace of a pale marginal rim on the carapace; (3) the lack of septal ridges in males; and (4) the presence of longitudinal corrugations on the posterior part of the carapace. We consider the closest living relative of *T. ater* to be *T. spinifer emoryi*. Both forms resemble *T. muticus* by virtue of reduction in size (*emoryi*) or complete loss (males of *ater*) of tubercles on the anterior edge of the carapace. Loss of the septal ridge in males of *T. ater* tends also to ally this species with *T. muticus* (septal ridges lacking in both sexes).

Trionyx ater is closely related also to *T. ferox* of Florida. Both species have an over-all slate or blackish dorsal coloration, lack a well-defined pattern on the limbs, and have at most a narrow or obscure pale marginal band on the carapace. In both species the carapace is ovoid and never has tubercles that are sharp-pointed or conical on its anterior edge. *T. ater* differs from *T. ferox* in having longitudinal corrugations on the posterior part of the carapace and no septal ridges in males. The corrugations suggest but differ from the longitudinal rows of tubercles in *ferox*. Both species have relatively restricted, southerly displaced, geographic ranges.

It is of interest that the male of *T. ater*, having a smooth anterior edge of the carapace, and no ridge projecting from the nasal septum, resembles *T. muticus* more closely than do the females of *T. ater*. Females of *T. ater* have a suggestion of tubercles along the anterior edge of the carapace, no pale marginal rim on the carapace, and corrugations on the periphery at the posterior end of the carapace, thus resembling *T. ferox* more closely than does the male.

Trionyx ater seems to be a relict population of pre-*spinifer* stock. Although the resemblance and relationship of *T. ater* and *T. s.*

emoryi is close, we consider *ater* a full species because of its geographical sympatry with *T. s. emoryi* and the apparent lack of populations intermediate between the two forms.

The sympatry of *T. s. emoryi* and *T. ater* is accompanied by partial ecological separation. Habitat preferences of the two species of *Trionyx* in the basin of Cuatro Ciénegas were evident in that only one specimen (KU 46907, adult male, Pl. II) of *T. spinifer emoryi* was obtained in the non-fluviatile water of the type locality of *T. ater,* whereas specimens of both sexes of *emoryi* [KU 46913-16 (and two specimens that escaped) Pl. I] but no specimens of *T. ater* were obtained in the Río Chiquito, 10 kilometers south of Cuatro Ciénegas. At the latter locality the river is 30 to 50 feet wide and has a swift current; vegetation of the quiet backwaters is much like that of the type locality of *T. ater* however (see discussion of habits and habitat). Much the same habitat relationship exists between *T. ferox* and *T. s. asper* in areas where the ranges of the two species overlap. Crenshaw and Hopkins (1956:16) stated, regarding the area of overlap of these two forms, ". . . *asper* is nearly always an inhabitant of fluviatile situations whereas *ferox* is equally closely confined to non-fluviatile lakes and ponds."

Studies of other species of aquatic vertebrates from the basin of Cuatro Ciénegas indicate that the pond habitats in the basin were isolated in the past and that because of this isolation speciation of vertebrates took place to varying degrees. The present external drainage of the area has permitted overlap and subsequent interbreeding of some of the previously isolated forms with those from the Río Salado and Río Grande drainages, whereas certain other species, through ecological specialization have been able to remain distinct. *T. ater* seems to be in the latter category. The fact that ecological separation of *T. ater* and *T. s. emoryi* is not complete indicates that interspecific matings, possibly resulting in hybrids, might occur. Matings of *T. spinifer* with *T. muticus* have been reported (Legler, 1955).

One of us (Webb) is currently undertaking a taxonomic study of American forms of *Trionyx.*

Habitat and habits.—Cuatro Ciénegas is situated in an intermontane basin, the floor of which has an elevation of approximately 2400 feet. The basin is approximately 30 miles long (from west to east) and five to 15 miles wide. The Río Chiquito (called "Río Colorado" by some natives), originates in the southwestern part, receives several intermittent tributaries within the basin, and flows out through a gap in the eastern end. The Río Chiquito flows

thence northeastward and joins the Río Salado near Hermanas, ultimately draining into the lower Río Grande near Zapata, Texas.

Much of the central part of the basin is marshy. The sandy slopes that lead up to the rocky sides of the valley are dry. A number of clear, deep ponds of various sizes, chiefly west and south of the town—as well as a hot spring approximately nine kilometers south of town—occur in the marshy areas. The ponds were previously isolated but are now drained (and interconnected) by small, man-made ditches that lead to larger cement-lined ditches. It was learned from natives that water remains in the ponds and in the Río Chiquito at all times of the year. Gilmore (1947:148-150, fig. 2) presented a brief but adequate general description of the valley.

The type locality of *T. ater* is a pond, having a surface area of approximately two and one-half acres, in the east-central part of the valley. The average depth of the pond was estimated to be six feet; holes two to three times as deep were observed in several places. Water in the pond is warm (approximately 80 degrees Fahrenheit) and clear, enabling one to see the bottom clearly in the deepest places. A narrow intermittent channel leads from the northern side of the pond toward the Río Chiquito, approximately four miles distant. Thick patches of submergent aquatic vegetation (chiefly stonewort, *Chara zelandica* var. *inconstans*) cover approximately half of the bottom; the remaining areas are bare, revealing a grayish sediment. Water lilies (*Nymphaea* sp.) grow in the shallower parts of the pond and thick stands of cattails (*Typha latifolia*) and spike-rushes (*Eleocharis rostellata*) grow in and near the water at the edges of the pond. The nearly flat area surrounding the pond is grassy or marshy for a distance of several hundred yards and then gives way gradually to xeric associations including cacti, yucca, and mesquite. The I. U. paratype was obtained in a similar but much smaller pond on the northern side of the basin.

Specimens of *T. ater* were captured, along with large numbers of *Pseudemys scripta,* in hoop-nets baited with canned sardines, rodent bodies, and fresh cichlid fish. Some turtles of both species entered the hoop-nets as soon as 30 minutes after fresh bait had been placed in the nets. Examples of *T. ater* seemed to be attracted by the small live fish that entered the nets as well as by the bait. The relative abundance of turtles in the pond, reckoned on the basis of trapping records, may be expressed as one individual of *Trionyx* per 4.2 individuals of *Pseudemys.*

The heads of several *T. ater* could usually be seen at dusk by scanning the surface of the pond with binoculars. No turtles were seen on the surface or beneath the water during daylight hours; it is assumed they sought cover beneath dense vegetation or in sediment at the bottom of the pond. Softshells entered hoop-nets at various times between dusk and dawn and continued to enter in the course of the day if the sky was overcast; success of trapping decreased sharply during periods of bright sunlight.

The stomach of one of the paratypes (KU 46908) contained 23 larvae of long-eared leaf beetles (Chrysomelidae: *Donacia* sp.) and many short pieces of roots of spike-rushes; the roots probably were ingested incidentally along with the larvae that were attached to them.

Remarks.—The second and third largest paratypes (KU 46906 and 46908) were dissected and found to have immature ovaries; probably, therefore, the holotype, a slightly larger specimen, is immature as well. Larger adults were probably unable to enter hoop-nets, the largest of which had openings slightly less than one foot wide.

Natives at Cuatro Ciénegas refer to softshell turtles as "*tortuga blanca*"; they make no distinction between *T. spinifer emoryi* and *T. ater*.

ACKNOWLEDGMENTS

We are grateful to Dr. Hobart M. Smith and Messrs. Pete S. Chrapliwy and Kenneth L. Williams for permitting study of material at the University of Illinois; to Messrs. Wendell L. Minckley and Robert B. Wimmer for assisting Legler with field work; and to Drs. George W. Byers and Ronald L. McGregor, respectively, for identification of insect larvae and plants. Special thanks are due Sr. Daniel Rodriquez Villarreal, Cuatro Ciénegas, who gave generously of his time in guiding the K. U. field party to the type locality.—*Museum of Natural History, University of Kansas.*

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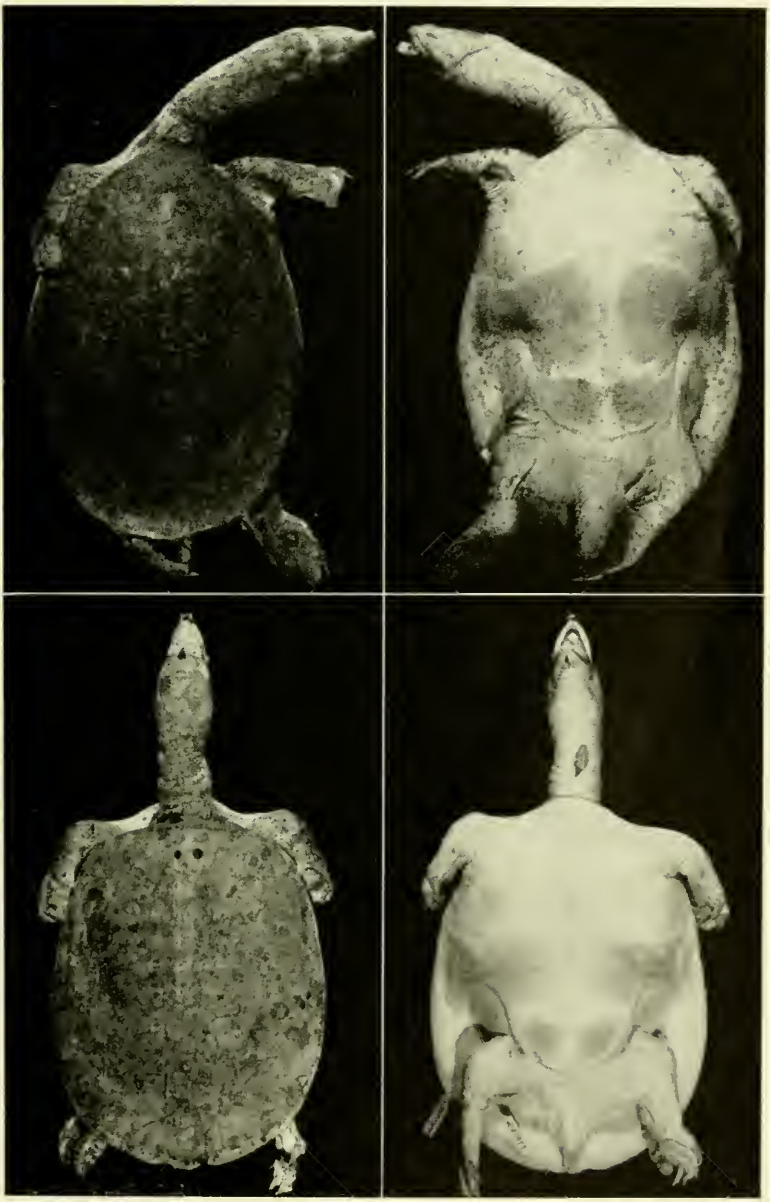
Measurements (in millimeters) of type and paratypes of *Trionyx ater* new species. Length of snout was measured from middle of tip of snout to anterior corner of eye. All measurements are maximal.

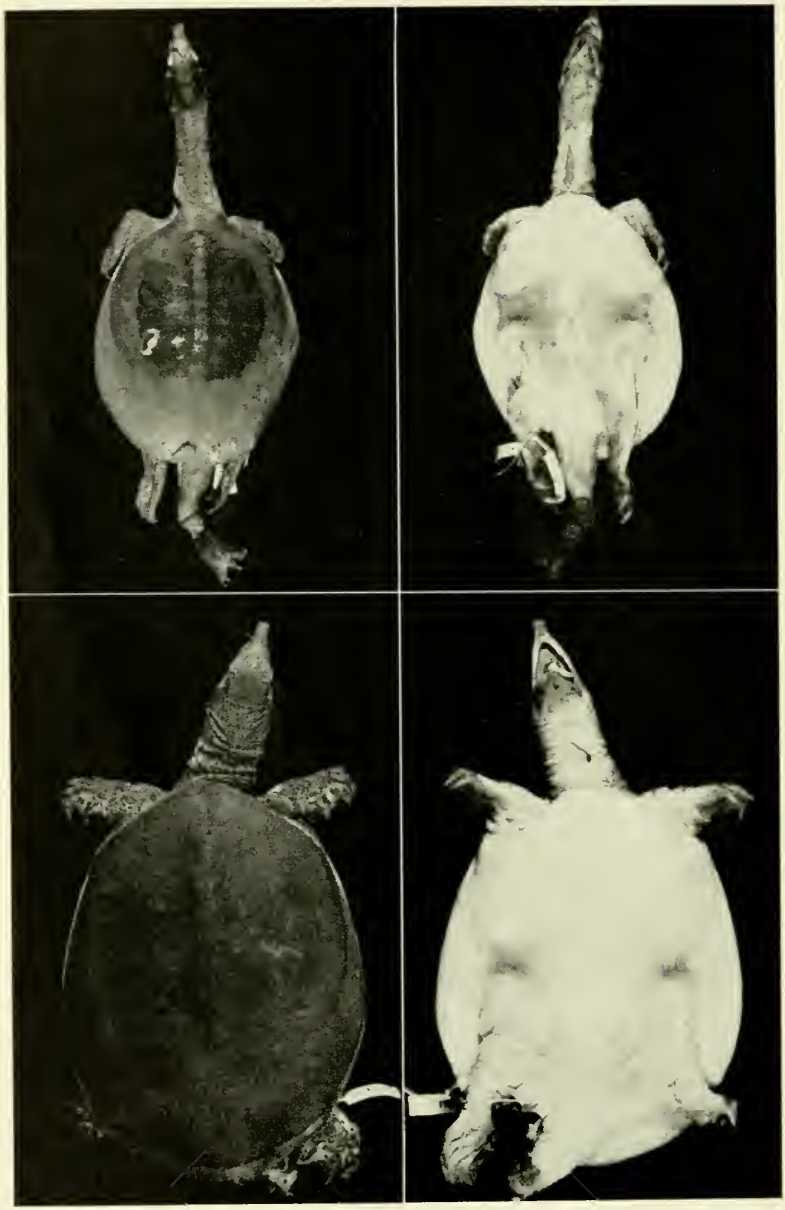
NUMBER	Sex	Length of carapace	Width of carapace	Length of plastron	Height	Width of head	Length of snout
KU 46903	♀	243	178	183	63	37	22
KU 46906	♀	231	181	172	66	37	22
KU 46908	♀	213	148	155	52	32	20
KU 46910	♀	211	152	158	53	29	18
IU 43510	♀	210	164	163	49	30	19
KU 46905	♀	205	156	151	51	32	20
KU 46912	♀	189	140	139	46	27	18
KU 46909	♀	186	142	136	47	28	18
KU 46904	♀	152	117	108	36	23	13
KU 46911	♂	134	108	95	41	22	14

PLATE I



Top. *Trionyx ater* sp. nov., dorsal and ventral views of holotype, KU 46903 (×⅕). Bottom. *Trionyx spinifer emoryi*, dorsal and ventral views of female (KU 46913) from Río Chiquito, 10 km. S Cuatro Ciénegas, Coahuila, Mexico (×¼).

PLATE II



Top. *Trionyx ater* sp. nov., dorsal and ventral views of adult male, KU 46911 (× ¼). Bottom. *Trionyx spinifer emoryi*, dorsal and ventral views of adult male (KU 46907) from type locality of *T. ater* (× ⅜).

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A New Caecilian Genus in India

BY

EDWARD H. TAYLOR

The Caecilian fauna of Pakistan and India has long been known to comprise species of four recognized genera: *Ichthyophis* Fitzinger, *Uraeotyphlus* Peters, *Gegeneophis* Peters, and *Herpele* Peters. A fifth genus is herein described. Some of the more obvious differences in the five genera may be expressed in the following key:

KEY TO ASIATIC CAECILIAN GENERA

1. Scales absent; one row of teeth in the lower jaw; tentacle cone-shaped, close behind and below nostril, nearer to tip of snout than to eye; squamosal and parietal bones in contact ..... *Gegeneophis*
   Scales present; one or two rows of teeth in the lower jaw 2
2. Eye hidden, covered by bone; tentacle conical, below and somewhat behind the nostril, closer to tip of snout than to eye, the tentacular opening circular; squamosal and parietal bones in contact ..... *Herpele*
   Eye not covered by bone, more or less visible; tentacle variable 3
3. Vent transverse; tentacular opening horseshoe-shaped, surrounded by a low craterlike elevation whose inner sides are marked with minute valleys and ridges (shape of extruded tentacle not known); tentacle situated directly in front of eye and on a level with nostril, but much closer to eye than to nostril, the tentacular groove on skull forming a forward extension of the orbit; (relation of skull bones to each other not known); no tail present, end of body rounded ..... *Indotyphlus*
   Vent longitudinal, a short pointed tail, bearing transverse folds 4
4. Tentacle flaplike, nearer to tip of snout than to eye, situated almost directly below nostril, near mouth; squamosal and parietal bones separated by a diastema; orbit not elongated forward; a prefrontal and postfrontal; no frontoparietal foramen; internal nares open between vomer and palatine; fewer than 200 folds, none angular ..... *Uraeotyphlus*
   Scales present under skin throughout body; tentacle conical, near edge of mouth, much closer to eye than to nostril; parietal and squamosal bones in contact; more than 200 grooves (or folds); one or two rows of teeth on mandible; folds on venter largely angular ..... *Ichthyophis**

* There is strong probability that when it is possible to study skulls of the various species now described, *Ichthyophis* will be found to consist of more than a single genus.

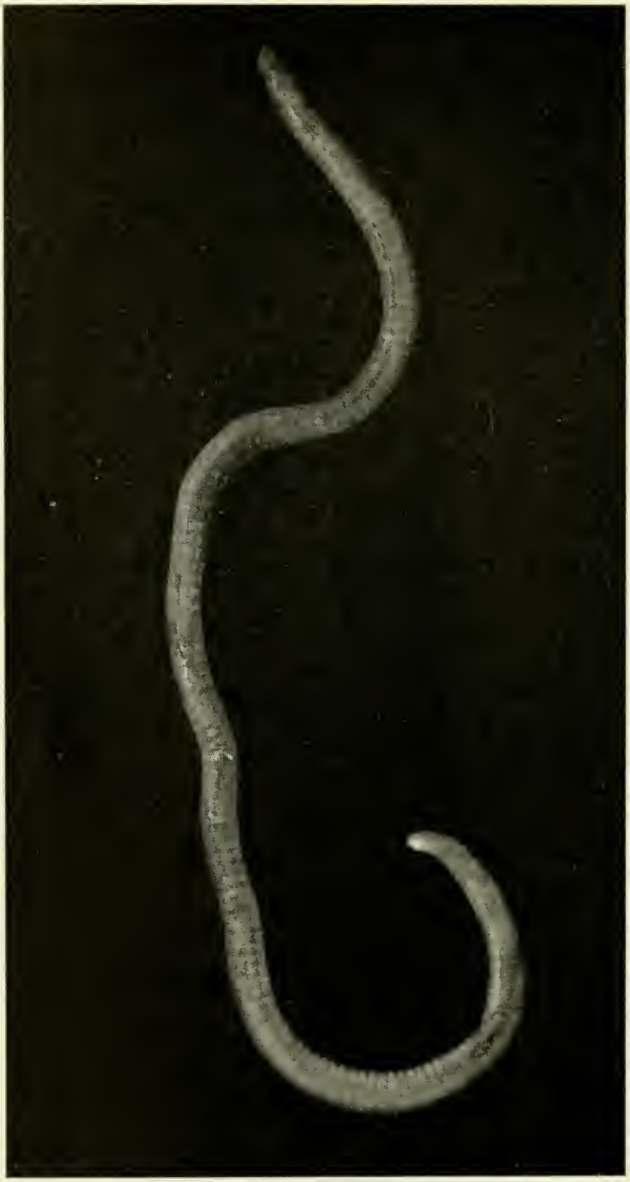

FIG. 1. *Indotyphlus battersbyi* sp. nov. Photograph of the type specimen. Actual length, 170 mm. Khandala, Poona District, India.

*Indotyphlus** gen. nov.

Type of genus: Indotyphlus battersbyi sp. nov.

Diagnosis: Anal vent transverse; no tail, the postanal region blunt, rounding, lacking transverse folds; 139 primary folds surround body; secondary folds present in posterior part of body only; eye concealed below skin and flesh; the orbital rim incomplete, the tentacular depression of skull continuous with the orbit; eyeball more or less imbedded on the base of tentacle which runs straight forward from orbit on level with nostril but emerges distinctly closer to eye than to nostril; vertebrae 144. A maxillary-premaxillary and vomeropalatine series of teeth in upper jaw; lower jaw with an outer mandibular series and a shorter inner splenial † series.

Indotyphlus battersbyi sp. nov.

Type: No. 49974 American Museum Natural History, from Khandala, Poona District, India.

Diagnosis: A slender species, the width in length approximately 46 times; secondary folds begin at about the 110th primary fold and scales present posterior to this point; eye concealed; tentacle on level with eye, nearer eye than nostril; elevation about tentacle craterlike.

Description of type: Body slender elongate; snout rather acuminate, projecting .75 mm. beyond tip of lower jaw; eye completely concealed below skin and flesh; tentacular opening, somewhat horseshoe-shaped, appearing at the bottom of a shallow crater whose inner walls are sculptured with ridges and valleys; (shape of exserted tentacle unknown but probably conical); width of head at mouth angle (3 mm.) slightly less than head length from mouth angle to tip of snout (3.25 mm.); length to tip of snout from first (incomplete) nuchal groove, 4.2 mm.; length from second (complete) groove, 5.6 mm.; from third (incomplete) nuchal groove limiting pharyngeal region, to tip of snout, 7.25 mm.

A short dorsal groove between first and second transverse nuchal grooves; a short lateral groove indicated between the second and third grooves; transverse costal (primary) folds and grooves surround body without forming a ventral angle, distinct except for a space in median dorsal area of back; primary folds, 139; the secondaries in posterior part of the body begin as short lateral grooves

* From Indo, referring to India, + typhlos Gr. = blind.

† In caecilians the inner mandibular series of teeth seemingly is equivalent to the splenial teeth of salamanders. In this paper they are called splenial teeth.

at the 110th fold and continue to back edge of vent growing longer, totalling about 29, only the last 13 surround the body completely; vent transverse, the edges denticulate; without grooves or folds; behind vent, the end of body blunt, rounded, its ventral surface a little flattened.

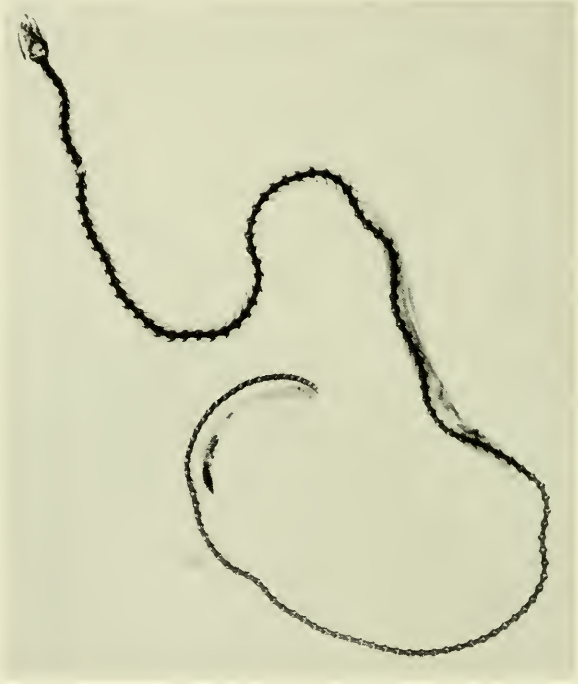

FIG. 2. Radiograph of the type of *Indotyphlus battersbyi* sp. nov.

Snout projecting a little beyond mouth; maxillary-premaxillary tooth series, 9-9 (allowing for missing teeth), the teeth nearly triple size of those in vomeropalatine series which number, 12-12; mandibular series, 9-9, distinctly larger than maxillaries; splenial series, 2-2, smaller than mandibular teeth; tongue small, pointed, not covering the splenial teeth; internal nares large, separated by a distance less than transverse diameter of one choana.

Glands of skin more or less equally distributed over body; a lateral ridge present, broken by grooves, usually distinct throughout; scales present in posterior part of body where secondaries are present, two series for each primary fold; each series with three

rows of imbricating scales that overlay each other; posteriorly extending entirely around the body; vertebrae 144.

Color (in preservative): Brown of a nearly uniform shade on dorsum and sides; head darker; slightly lighter brown ventrally; a somewhat lighter area near vent.

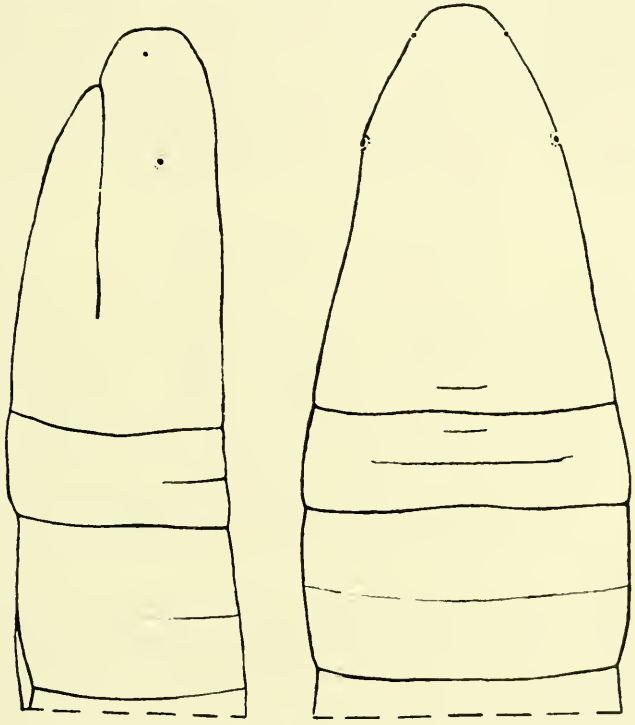

Fig. 3. Diagram of the head and anterior part of the body of *Indotyphlus battersbyi* sp. nov., showing the relative position of nostril and tentacle. The eye is not visible. From type, × 12.

Measurements in mm.: Total length, 170; head width, 3.5; head length, 4.7; body greatest width (approximately), 3.7; width in length approximately 46 times.

Remarks: The detailed characteristics of the skull are as yet unknown. When this can be studied, more complete knowledge of the relationships of *Indotyphlus* with other genera will be learned.

The type may be one of the specimens collected by Charles McCann at Khandala, Poona District, and reported by him as *Ichthyophis monochrous* Boulenger, in the Journ. Bombay Nat. Hist.

Soc., vol. 31, no. 4, Feb. 20, 1927, p. 1039. He states "When at Khandala during the month of September, 1919, I secured several specimens of this batrachian. It lives under stones during the rains in burrows much after the fashion of the earthworm which it also resembles in its movements. At first sight it might well be mistaken for one of these creatures as its body is also coated with slime. On the removal of the stone under which it lives the animal soon begins its descent into its burrow away from the light."

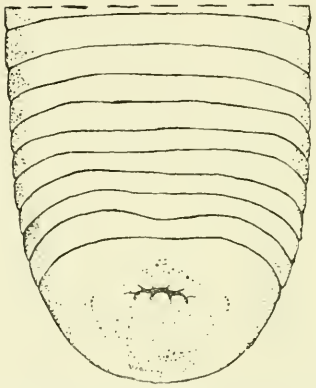

FIG. 4. Terminus of the body of *Indotyphlus battersbyi* sp. nov., showing absence of a tail and the transverse vent. From type, × 12.

In the same Journal, vol. 42, part 1, 1940, on p. 64 Mr. McCann writes: "On the 6th September 1931 while collecting frogs I discovered another specimen (of *Ichthyophis monochrous*) living under a stone on the banks of the lake behind a range of hills locally called the 'Sausages.' I have repeatedly hunted for this animal since its first discovery at Khandala, but without much success. The 1931 specimen measured 232 mm."

I suspect that this second report represents a totally different species.

The species is named in honor of Mr. J. C. Battersby of the British Museum of Natural History.

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On the Caecilian Species *Ichthyophis glutinosus* and *Ichthyophis monochrous*, with Description of Related Species

BY

EDWARD H. TAYLOR

ABSTRACT: The Asiatic forms of the genus *Ichthyophis* are considered. The species generally recognized as *Ichthyophis glutinosus* and *Ichthyophis monochrous* were each found to consist of several species. The species described by Taylor, *Ichthyophis glandulosus* and *Ichthyophis weberi* synonymized by Inger are resurrected and recognized, and the following species synonymized by Boulenger and others are revived: *Ichthyophis tricolor* Annandale, *I. beddomei* Peters. *Ichthyophis monochrous* Bleeker is recognized and is believed to be confined to the island of Borneo. *I. glutinosus* Linnaeus is likewise recognized as an Asiatic species.

Larvae from a number of places were examined. Certain of these seemingly belong to species whose adults have not been seen and are probably undescribed. No attempt has been made to utilize larvae as types of species.

The following forms are described as new species: *Ichthyophis dulitensis, I. larutensis, I. paucidentulus, I. singaporensis, I. peninsularis, I. subterrestris, I. bombayensis, I. mindanaoensis, I. javanicus, I. malabarensis, I. youngorum, I. sikkimensis, I. sumatranus, I. acuminatus, I. nigroflavus, I. paucisulcus, I. supachaii, I. kohtaoensis.*

A number of specific characters have been considered that have been heretofore largely neglected. These are the character and distribution of the scales, the continuity or discontinuity of the folds and grooves around the body, the presence or absence of a row of splenial teeth (second mandibular series), the number, relative size and characteristics of the other dental series, and the length and characteristics of the tail.

In the larvae the lateral line system (neuromast) varies much and seems to reflect habits of the young. Certain of the larvae have only a single gill slit; others have two well-developed slits.

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INTRODUCTION

In the work of Seba[1] (Thesaurus, vol. 2, 1735) a species of caecilian was described briefly under the name Serpens caecilia ceylonica, Ceylon being the type locality of the species. Here it was presumably considered as a snake.

Nineteen years later, in 1754, Linnaeus listed two caecilians in a work, "Museum S. R. M. Adolphi Friderici." . . . These were *Caecilia tentaculata* from South America and *Caecilia glutinosus*, a new species described with "Habitat in Indiis."

The description of *glutinosa*, published both in Latin and Swedish,

1. Seba, A. Locupletissimi naturalium thesauri accurata descriptio et iconibus artificio sissimus expressio, per universam physices historiam. Vols. 1-4, 1734-1763, 449 pts. Amsterdam. (Vol. 2 published in 1735.) A copy of this description, vol. 2, p. 26, was published in Taylor, Univ. Kansas Sci. Bulletin, vol. 38, pt. 2, no. 13, Mar. 20, 1958.

though brief, is scarcely sufficient to distinguish an Indian or Asiatic species. The description in Latin reads as follows:

Caecilia glutinosa

"*glutinosa* Caecilia rugis transversalibus 340, caudalibus 10.

"*Caput* parvum, laeve. *Narium* foramina in antica parte capitis. Cirrhos nullos observare potui. *Oculi* minutissimi, membrana abducti. *Dentes* utriusque maxillae minimi, serie duplici.

"*Truncus* cylindricus, versus posteriora paulo crassior: Rugis minutissimis, vix visum subeuntibus, a tergo retrorsum nonnihil flexis at futuram abdominis, coëuntes angulo acuto. *Rugae* majusculae circiter 350.

"*Cauda* brevissima acutiuscula. anus sub & juxta apicem caudae.

"*Color* fuscus: linea utrinque laterali albida, latiuscula.

"*Longitudo* pedem superat. Crassities digiti minimi.

"*Glutine* vedetur viva esse obducta uti petromyzon."

Further data from the type specimen is necessary before this species can be placed properly.

Anderson (1899), Catalogue of Linnean type specimens of Snakes, Bihang Till K. Svenska Vet.-Akad Handlingar, Band 24; Afd. 4, No. 6, page 6, states that 355 folds are present and that the length is 400 mm.

The description is scarcely adequate for distinguishing a species of Indian caecilian. Linnaeus states that he has not observed a tentacle on the head; however one must presume that a tentacle *is* present. That it is not a larva is presumed by the fact that neither gill slits (spiracles) nor a tail fin are mentioned. The species under the same name is listed by Linnaeus in the 10th edition of the Systema Naturae (p. 229).

Certain subsequent authors have used other names presumably in reference to the Linnaean species. Thus Latreille lists *Coecilia viscosa* as a substitute name[2] and Cuvier uses the name *?Coecilia bivitatta* in the Regne Animal (1817, p. 100) while on another page (tome 2, p. 87) the Linnaean name is used.[3]

In 1826 Fitzinger[4] proposed the taxon *Nuda* for his fourth tribe (Tribus) of the Reptilian, Order (Ordo) Menopnoa. The first and only family designated in this was *Coecilionidea*. He included in it the genera *Caecilia* Linnaeus [= Coecilia Cuvier] (using the spelling given by Cuvier rather than that given by Linnaeus), and a new genus *Ichthyophis*. Of these he states:

2. Latreille, P. A. In Sonini and Latreille, Histoire naturelle des Reptiles. Vols. 1-4, 1802, p. 236.

3. Le règne animal distribué d'après son organization, pour servir de base à l'Histoire Naturelle des Animaux et d'introduction à l'Anatomie comparée, vols. 1-4, 1817, Paris.

4. Neue Classification der Reptilien nach ihren natürlichen verwandschaften nebst einer verwandschafts—tafel und linem verzeichnisse der Reptilien—Sammung des K. K. zoologischen Museum's zu Wien". 1826, pp. 1-66, 1 table. F. G. Heubner, Wien.

Isolirt steht diese Familie in der Zunft der Nuden, das Bindungsglied der Monopnoën mit der Dipnoën bildend. Beim Ueberblicke der Arten der Cuvier'schen Gattung Coecilia zeigt sich sogleich in der Totalform eine Hauptverschiedenheit, welche zur Trennung meiner Gattung Ichthyophis Veranlassung gegeben hat. Linne's Caecilia glutinosa und eine Art aus Java haben einen deutlich plattgedrückten Körper mit zugespitztem Ende, welcher den übrigen Coecilen durchaus fehlt, und hierauf ist der generische Unterschied gegründet. Coecilia bildet den schönsten Uebergang zu Leposternon aus der Zunft der Squamaten, und durch Ichthyophis zu Amphiuma, Siren und Pseudobranchus, aus der Zunft der Immutabilien in der Ordnung der Dipnoën."

Subsequent to the proposal of the genus *Ichthyophis*, Fitzinger proposed the name *Ichthyophis Hasseltii* for a species based on a specimen in the Vienna Museum from Java. One is forced to conclude that the *Ichthyophis Hasseltii* of Fitzinger is a *nomen nudum* since he offers only the following meager data on the specimen:

Page 36: *Caecilia glutinosa* and a new species from Java have a distinct "plattgedruckten" body with a "zugespitztem Ende."

Page 63. Fitzinger lists species present in the Vienna Museum: *Coecilia annulata* and *C. lumbricoides* respectively from Brasil, and an unknown locality; and a third species, *Ichthyophis Hasseltii*, from Asia, Island of Java.

These data seemingly cannot distinguish *hasseltii* from certain other species of *Ichthyophis* now known.

The following year Van Hasselt, in Isis, 1827, p. 565, under the name *Coecilia hypocyanea* described a species from Java in the Vienna Museum, presumably the same specimen that served as the basis for the name *I. hasseltii*. The description follows:

"Capite indistincto, depresso laevissimo, tentaculato, tentaculo ad marginem maxillarum utrinque anteorbitali minuto, oculis parvis hebetibus, cauda brevissima, trunco fusiformi, capite paulo latiori, rugis 320 circiter sutura abdominali oblique interruptis, arctissime annalato. Supra ex olivaceo obscura, subtus chalybea linea laterali flavopunctata;"

The following authors have used this name and figured the form: Müller 1835, p. 391, pl. 8, figs. 12-14. Schlegel, 1832-1844, p. 119, pl. 39, fig. 1. Wagler, 1828, p. 743 reports this species as *Epicrium Hasseltii*. "Corpore supra obscure olivaceo, subtus chalybeo-caeruleo, lateribus lineis duabus maculosis flavo ochraceis picto; trunci rugis circiter 320. Habitat in Java insula locis paludosis Javanis Octur-doeël dictum."

The original description of *Ichthyophis monochrous* was published by Bleeker (Nat. Tydschr. Nederl. Indië, vol. 16, 1858) as *Epicrium monochroum*, in section 7 of the generalized title—"Bestuursvergadering gehouden ten huize van den Heer De Bruijn Kips den 11 Maart 1858."

The section 7 begins: "De Heer Bleeker deelt made, dat hijdezer

dagen weder eene verzameling reptilien en visschen van Sinkawang (westkust van Borneo) ontvangen heeft.

"Deze verzameling is, evenals vroegere van Sinkawang, aangeboden door het lid der Vereeniging, den heer J. H.A.B. Sonnemann Rebentisch.

"De reptilien bestaan uit de folgende soorten." . . . [On page 188 the following description appears]:

"No. 15 *Epicrium monochroum* Blkr.

"De hèer Bleeker vertoont laatstgenoemde soort in een voorwerp van 232 millimeters lengte. Het is van eene violetbruine kleur over het geheele ligchaam en slechts iets lichter gekleurd aan de ondervlakte van den kop, terwijl de anus door eene witachtiggele vlek omringd is. De overlangsche gele band van Epicrium glutinosum Wagl. ontbreekt volkomen. Ook zijn er niet, zooals de heer A. Duméril van Epicrium glutinosum opgeeft, 325 volkomene cirkelvormige huidplooijen maar slechts 246 plooijen in het geheel, welke alle aan de buikvlakte een' stompen naar achteren gerigten hoek vormen. De hoogte des ligchaams gaat ovgeveer 25 malen in zijne lengte. Het kuiltje onder de oogen bestaat doch is zeer oppervlakkig, heeft weinig verhevene randed en ligt nabij de bovenlip een weinig voor het oog. De schubjes zijn uiterst klein. Het ligchaam is aanmerkelijk dikker in het midden dan aan het kop-en staarteinde. De heer Bleeker beschouwt het voorwerp op grond der genoemde kenmerken als eene eigene soort, welke vrij aanmerkelijk van Epicrium glutinosum verschilt."

Peters,[5] in 1879 described a species from India under the name *Ichthyophis beddomii* while a second Indian form was named *Ichthyophis glutinosus tricolor* by Annandale in 1909.[6]

Boulenger in the "Catalogue of the Batrachia Gradientia *s* Caudata and Batrachia Apoda in the collection of the British Museum" (1882) recognizes only two species in the genus *Ichthyophis* and Boulenger has been largely followed by all subsequent writers dealing with the genus.

Thus the genus *Ichthyophis* for more than half a century was generally regarded as comprising only two species of caecilians. One, the species *Ichthyophis glutinosus*, described by Linnaeus in 1758 whose range came to be defined as extending from the East Indies through southeastern Asia to India. The second species, *Ichthyophis monochrous* described by Bleeker in 1858 was sup-

5. Mon. Akad. Berlin 1879, p. 931.
6. Rec. Indian Mus., vol. 3, 1909, p. 286.

posed to range from Borneo through Java, Sumatra, Malaya, Siam, Ceylon, and India, to Sikkim.

In 1920 I obtained a specimen of a caecilian discovered by C. M. Weber [7] on Palawan Island, Philippine Islands. This I described as a new species, *Ichthyophis weberi* differing, among other characters, from *I. monochrous* in lacking the inner row of mandibular teeth (splenials) and in having some 78 more circular folds about the body [8] characters which an experienced taxonomist probably would accept as being worthy of designating a different species.

In 1923 I discovered still another form of caecilian on Basilan Island, Philippine Islands, which was named *Ichthyophis glandulosus.*[9]

The published ranges of these two species, *I. glutinosus* and *monochrous,* were truly surprising. It became apparent that a remarkable happening had taken place in the southeastern part of the range of the genus in the Philippines and Borneo where no less than three species were present; while no change was recognized in the two species which purported to extend from Borneo to Sikkim in the Himalayas, and to Ceylon, a distance of several thousand miles.

It is almost an axiomatic rule that genera of low vagility tend, as they spread, to speciate to a greater degree than those of greater vagility. Burrowing genera of reptiles and amphibians are perhaps the least vagile of all the vertebrates. But here were two recognized species of burrowing caecilians whose ranges were enormous and in which, presumably, there had been little species formation, thus contradicting the generally accepted belief. This problem definitely merited investigation, to account, in some way, for this lack of plasticity in the genus, or to prove that such ranges did not exist.

On the basis of experience in the Philippines, I concluded that most evidence pointed to the fact that previous authors had in some manner confused species (since extraordinary variation in the number of the primary and secondary folds had been recorded in the literature), and that we were dealing with species—perhaps

7. Later killed by natives on the nearby island of Balabac.

8. This form has recently been placed by Dr. Inger in the synonymy of *Ichthyophis monochrous.* This should be disregarded, largely because the author has a different concept of species (his own statement), because of his inexperience with Amphibia, and perhaps his lack of knowledge that much caecilian material in museums is misidentified.

9. This form also was relegated to the synonymy of *I. monochrous* by the same author as the preceding. He comments that the lateral fold is not glandular, despite the fact that on it many hundreds of glandules are present. He states, "*Ichthyophis glandulosus* Taylor is probably conspecific with *monochrous* Bleeker. I am unable to find distinguishing characters" . . . this statement I believe, is made by Inger without his having seen a specimen of either *monochrous* or *glandulosus.* His action I believe should be disregarded for the reasons set forth in the preceding footnote.

even generic complexes in the nominal *Ichthyophis monochrous* and *Ichthyophis glutinosus.*

In 1958 I discovered certain undescribed species of the genus in Thailand, definitely not to be associated with either *monochrous* or *glutinosus.* On my return journey from Thailand to America I visited museums in Ceylon, Germany, France, and England and examined the specimens classified under the two above names. I found that my tentative conclusion was confirmed—that several undescribed species were masquerading in museums under the names *Ichthyophis monochrous* and *I. glutinosus.*

Through the kindness of the staffs of the various museums I was permitted to record data or borrow specimens for later study. Further material was made available by certain American museums. There follows here a review of most of the available material with the results of my study.

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TAXONOMIC CONSIDERATION

Ichthyophis weberi Taylor

Ichthyophis weberi Taylor, Philippine Journ. Sci., vol. 16, no. 3, March 1920, pp. 227-228 (type locality, Malatgan River, Palawan, P. I., C. M. Weber coll.); Dept. Agri. Nat. Resour. Bureau Sci. Manila, Publ. 15, December 15, 1921, pp. 26-27 (reprint of preceding type description).

Ichthyophis monochrous van Kampen (*part.*), The Amphibia of the Indo-Australian Archipelago. Leiden, 1923, pp. 3-4, 282 (synonomy questioned); Inger (*part.*) Fieldiana: Zoology, vol. 33, no. 4, July 23, 1954, pp. 207, 209 (unquestioned synonymy).

Type: Formerly, No. B-1, Bureau of Science collection; collected at Malatgan River, Palawan, January 28, 1909, by C. M. Weber.

Description of type: "Two rows of teeth in upper jaw, the series forming oval arches, parallel to each other, the inner row extending much farther back than the outer but not widening; lower jaw with a single row of teeth, with no evidence of a second row; head oval, eyes distinct, the distance between them very slightly less than width of head between eyes; distance between eyes a little greater than length of snout; tentacle withdrawn, the groove rather moon-shaped, situated anterior to eye near the edge of upper jaw;

body surrounded by three hundred twenty-four circular folds meeting on belly in an angle, except those on posterior part of body, which run straight across without an angle; the first three or four folds on anterior part of body fail to meet; a more or less distinct groove from tip of lower jaw to some distance in front of anus along the median ventral line of body.

Color in alcohol: "Above yellowish brown, somewhat darker on median part of body; below lighter yellowish brown. Under a microscope the color appears as minute rounded yellowish dots surrounded by a network of brown. A white spot on tip of lower jaw."

Measurements of Ichthyophis weberi Taylor

	mm.
Total length	250.
Tail	2.5
Width of head at eyes	7.5
Length of snout	5.
Eye to nostril	3.5
Eye to tentacle	1.5

Remarks: To the best of my knowledge no specimen other than the type has ever been taken of this species. I know of no scientific expeditions that have been undertaken in the island of Palawan in recent years.

I visited the Bureau of Science in Manila in September 1957 with the intention of re-examining the type specimen of *Ichthyophis weberi,* only to learn that the type together with all the extensive herpetological collections of the Bureau of Science, largely brought together by me, had been destroyed during the second World War.

Ichthyophis larutensis * sp. nov.

Ichthyophis monochrous Flower** Proc. Zool. Soc. London, 1899, (Nov. 14), p. 916 (not of Bleeker).

Type: British Museum Natural History, No. 98.9.22.208, Larut Hills (near Maxwell's Bungalow), Perak, Malaya, elevation 3,380 ft. Stanley Smyth Flower collector. (A second specimen mentioned, see footnote.)

* Larut (Mts.) + ensis (Latin) = place, locality, country.

** Flower comments on the form: "In April 1898 on different days I obtained two specimens from under a stack of firewood near 'Maxwell's Bungalow' in the Larut Hills, Perak, elevation 3380 feet.

"1st. Number of circular folds about 313; length 208 mm.

"2nd. Number of circular folds about 309; length 167 mm.

"As in *I. glutinosus,* some of the circular folds either bifurcate or converge into each other; therefore the number, in counting the same individual at different parts of its circumference, varies.

"*Colour* (in life): Uniform purplish black. Tentacles white. Anal region and tip of tail pale pinkish. The eye appears as an inconspicuous black speck (but turns whitish in spirits)."

Fig. 1. *Ichthyophis larutensis* sp. nov. Type B. M. N. H. No. 98.9.22.208, Larut Hills, Perak, Malaya, elev. 3380 ft. Actual length, 169 mm.

Diagnosis: A slender species, the body width in length, 30.7 times; tail length in body length, 48.3 times; transverse folds do not cross back in anterior three fourths of the body; approximately 304 transverse folds ("about 309" counted by Flower *loc. cit.*); folds on tail, 7; no splenial teeth present; tentacle nearer to eye than to nostril. Vertebrae, 107.

Description of type: Head slender, oval, the width at first nuclial groove, 5.1 mm.; the head length, 11 mm.; eyes distinct, the pupil white, surrounded by a narrow black iris; this in turn surrounded by a narrow cream ring; distance between eyes, measured on the curve, 3.8 mm., a little broader than length of snout (3.5 mm.); tentacle close to lip, nearer to eye (1 mm.) than to nostril (1.8 mm.).

First transverse nuchal groove crosses throat, runs upward and somewhat posteriorly, but fails to cross the head completely; the second groove crosses throat and goes up on side of neck nearly to dorsal level of neck; the third groove is distinct ventrally only and is rather widely separated from the second, forming a median angle below; primary and secondary grooves and folds about 304; they do not cross the middle line of the back except on the posterior fifth of the body; medially they fail to cross venter completely on anterior part of body; eight folds on tail counting from front of vent; tip of tail rather sharply pointed; a slight longitudinal groove on back part of chin connecting with the second groove.

Scales are absent, or minute and scattered in the anterior third of the body; posteriorly they are larger but consist usually of a single overlapping row in each fold.

Teeth: maxillary-premaxillary, 21-20, those on the premaxillae largest; vomeropalatine, 19-19; mandibular, 19-19; splenial, 0-0; tongue well developed covering entire area between maxillary-premaxillary series, not suggesting a recent transformation from the larval state; vertebrae present, 107.

Color in life (*fide* Flower): "Uniform purplish black, tentacles white; anal region and tip of tail pinkish;" at present the general color is dark brown; a cream-white spot on tentacular area and one about nostril; the grooves on throat are cream; lips lighter than head; the tip of tail and anal region cream.

Measurements in mm.: Total length, 169 (*fide* Flower, 167); tail, 3.5; body width, 5.5; width of head, 5.1; length of head, 11.

Remarks: The failure of the transverse folds and grooves to cross the back except in the posterior fourth is a significant character.

The light marks on the throat, the character of the third groove, the absence of the splenial teeth, and the pink spots at vent and tail-tip clearly delineate this form.

Two larval species of caecilians obtained in Perak are treated here. I am convinced that neither are the young of *Ichthyophis larutensis.*

Fig. 2. *Ichthyophis larutensis* sp. nov. Type. Radiograph showing 107 vertebrae

Ichthyophis sp. (1)

A series of fifteen larval specimens taken "near Yum River, headwaters Plus River, East Perak, Malaya, 2000 ft." and bearing the British Museum numbers 1935.5.21.51 to 1935.5.21.65, cannot be

placed definitely in a recognized species. In fact it would appear that two forms are represented in the material, and neither of them is the young of the species described here as *larutensis.*

The specimens were all taken in March 1923. They resolve themselves on the basis of length measurements into possibly three (presumably age) groups as indicated in the following table. These groups are not clearly limited, a fact which suggests that the reproduction period during a year is a rather extended one.

The table includes data on a second larval form (B. M. 1934 .5.21.50) and the type of *Ichthyophis larutensis.*

Data on two larval forms of Ichthyophis, and I. larutensis sp. nov.

NUMBER	Total length	Width	Width in length	Transverse folds	Max-premaxillary teeth	Vomeropalatine teeth	Mandibular teeth	Splenial teeth
1934.5.21.65	56	.....	.....	.....	.....	.....	.....	.....
64	62	.....	.....	.....	.....	.....	.....	.....
63	65	.....	.....	.....	.....	.....	.....	.....
64	65	.....	.....	.....	.....	.....	.....	.....
62	70	.....	.....	.....	.....	.....	.....	.....
1934.5.21.60	98	4.8	20	244	.....	.....	.....	.....
59	103	5	20.5	255	12–14	15–16	13–13	4–4
53	113	5.7	20	247	13–14	15–15	13–13	4–4
55	115	6	19	240	13–14	17–17	13–14	4–4
58	122	6	21	266	15–14	15–17	15–16	4–5
1934.5.21.56	132	7	19	249	13–13	18–18	16–15	5–5
54	137	7.3	18.7	257	15–15	21–21	17–16	5–5
52	140	7.2	20	261	14–14	18–18	15–15	5–5
57	140	7.1	20	268	15–14	18–18	18–18	5–5
51	141	7.2	20	265	13–14	17–18	14–15	5–5
1934.5.21.50*	184	8	23	348	13–14	18–18	20–20	7–7
98.9.22.208**	169	5.5	30	304	21–21	20–19	20–20	0–0

* Second larva.
** Type of *larutensis.*

The folds and the teeth on the youngest specimens cannot be counted. The eyes are indicated by rounded milky-colored areas, through which the eyeball is rarely visible. The tentacular opening is indicated either by a shallow pit or an opening (in older specimens) in the anterior part of eye-spot. The tail fin begins on the

dorsal part of the body about one or two millimeters in advance of the vent and continues around the end of the tail then forward to the back end of vent. The nostrils are terminal and not visible directly from above.

The gill opening is single with short free flaps preceding and following it; the transverse folds meet in the median ventral line at a sharp angle throughout most of the body except the part in front of the vent where they are almost straight across the venter. Six or seven folds are on the tail (counting from the front of the vent). The variation in the number of body folds in the specimens counted vary from 240 to 268. It is believed that much of this variation is sexual, females having the higher counts in at least some species.

Ichthyophis sp. (2)

A single specimen, B. M. No. 1934.5.21.50, taken in the locality "near Yum River, headwaters of Plus River, East Perak, 2000 ft." Malaya, differs from the preceding series in such a way as to suggest that it represents a different species.

The chief apparent differences from them are: the color is dark lavender to plumbeous instead of brownish; ten folds on tail (from front of vent) a somewhat larger series of splenial teeth; an increase of 80 transverse folds above the highest in the other lot. (See table for further data.)

That neither of these larvae is the young of *Ichthyophis larutensis* sp. nov. herein described, may be deduced from the presence of splenial teeth in the two types of larvae. These are absent in *larutensis* which is a slenderer form, transforming at a distinctly smaller size than the preceding larvae.

Ichthyophis paucidentulus sp. nov.

Type: U. S. N. M. No. 70671. Kapahiang, Sumatra; H. C. Kellers, collector.

Diagnosis: A presumed medium-small species having a barely discernible light streak on the side of body beginning at mouth angle, discontinuous in numerous places; no trace of splenial teeth, or of a ridge on inner side of jaw; eye moderately distinct through a gray-white spot in the eye-area (in preservative); tentacular opening lunate, relatively large, the tentacle conical, closer to eye than to nostril; the accessory cusp is clearly visible on the front teeth of maxillary and mandible; transverse folds, 393, 7 on tail; vertebrae, 122.

Description of type: A medium-small, slender specimen, the width in length, 34.5 times; head short, oval, the eyes dimly visible through a gray-white circular mark; head width at first nuchal fold, 8 mm.; length of head, 11.5; distance between eyes (6 mm. on curve) greater than snout length (4.9 mm.); eye to nostril, 3.2 mm.; tentacle conical, the tentacular opening lunate, above rather than behind tentacle, closer to eye (1.4 mm.) than to nostril (3 mm.); distance from tip of snout to first nuchal groove, 10 mm.; to second, 13; to third, 17.5; first nuchal groove distinct on throat, not crossing top of head; second visible below and on sides of neck; third indicated laterally but barely traceable across neck.

Primary and secondary folds, 393, counted on dorsum (fewer, 380 counted ventrolaterally); only a few anterior folds fail to meet; other folds on venter meet at an angle, directed backwards; each fold crosses the dorsum in a sinuous line and forms a convexity directed forward on median line, its anterior position on dorsum often from four to seven millimeters in advance of the ventral angle; posteriorly a few folds cross the body and venter almost directly. The grooves do not cross venter except posteriorly, in front of vent; four folds interrupted by the vent; no glandules * discernible on sides of vent; tip of tail somewhat flattened on top, not or scarcely compressed laterally.

Very small scales can be found in folds near the anterior part of body, absent or scarce on the ventral region anteriorly; more posteriorily the scales are larger and encircle body, about three imbricating rows in each fold.

Teeth: maxillary-premaxillary teeth, 25-27; vomeropalatine, 29-30; mandibular, 23-24; no trace of splenial teeth nor of the inner ridge or elevation that supports the splenials; most of the teeth have an anterior accessory cusp well developed, the teeth hooked; mandibular teeth larger than the maxillary-premaxillary series, and these in turn distinctly larger than the vomeropalatines; tongue large and rather thick, occupying all the space between the side of jaws; choanae elongate, somewhat angulate on inner border, separated by a distance slightly greater than twice the transverse diameter of one.

Color in preservative: Plumbeous on dorsum and sides; ventrally the shade is somewhat lighter; an indistinct, narrow, broken lateral line of dull cream from angle of mouth to near level of front of vent; a cream spot surrounds vent, widened at front end; tip of tail with

* These small glandules may be present only in males.

a small cream spot; a gray-white spot surrounding and covering eye; light whitish cream spots about tentacle and nostril.

Measurements in mm.: Total length, 294; tail, 6; head width, 8; head length, 11.5; estimated body width, 8.5; width in length, 34.5 times; tail length in total length, 49 times.

Remarks: This species on the basis of the increased number of vertebrae, and the lateral stripe, might seem to be closely allied to *Ichthyophis glutinosus.* This is highly improbable since the entire series of the splenial teeth is absent, and the jaw modified so that the usual inner ridge that bears the splenials is likewise absent. It probably is most closely related to *I. nigroflavus* sp. nov.

The secondary cusp on the teeth is more or less indicated in many species. In this form the size of the teeth makes the cusps more evident. The number of the maxillary-premaxillary and vomeropalatine teeth is, I believe, exceeded only in the largest known species, *Ichthyophis nigroflavus* sp. nov. and *I. malabaricus* sp. nov. On the other hand it would appear that the mandibular teeth are somewhat reduced in number.

The name *paucidentulus* is derived from Latin *paucus,* few; *dentalus,* toothed, in reference to the fact that there are only three instead of four sets of teeth.

Ichthyophis monochrous (Bleeker)

Epicrium monochroum Bleeker, Nat. Tijdschr. Ned. Ind., vol. 16, 1858, p. 188 (type locality Sinkawang west Borneo); Günther, The Reptiles of British India, 1864, p. 443 (*part.*) (refers a specimen from Singapore to this species, specimen having 226 circular folds); Proc. Zool. Soc. London, 1872, p. 591 (listing only).

Ichthyophis monochrous Peters, Monats. Akad. Berlin, 1879, p. 932 (*part.*); Boulenger, Catalogue of the Batrachia Gradientia *s.* Caudata and Batrachia Apoda in the collection of the British Museum, p. 91, pl. 4, fig. 1 (*part.*); Boettger, Ber. Senckenberg. Nat. Ges., 1887, p. 50; Boulenger, The Fauna of British India, including Ceylon and Burma. Reptilia and Batrachia, 1890, 517 (*part.*) (! Java, Borneo, Singapore, Sikhim and Western Ghats of India, Malabar, Waghei Surat, India); Proc. Zool. Soc. London, 1895, pp. 403-404 (*part.*); ? de Elera, Catalogo Sistematico de toda la Fauna de Filipinas. . . . 1895, p. 453; van Kampen, Amphibien des Indischen Archipels. Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien, herausgegeben von Dr. Max Weber, 1907, p. 415 (*part.*); Nieden, Das Tierreich. Lief. 37 1913 Gymnophiona, Berlin, p. 7 (*part.*); Bourret Les Batraciens de l'Indochine (? date), pp. 138-139, fig. 15 (*part.*).

Type: British Museum Natural History No. 63.12.4.5 Sinkawang, west Borneo.

Diagnosis: Vertebrae, 108; costal folds, aproximately 247; length in width about 22-23 times; splenial teeth reduced, 4-4; four to five scalerows in each fold, at least in posterior half of body; four anterior folds fail to meet (ventrally); transverse folds cross the body

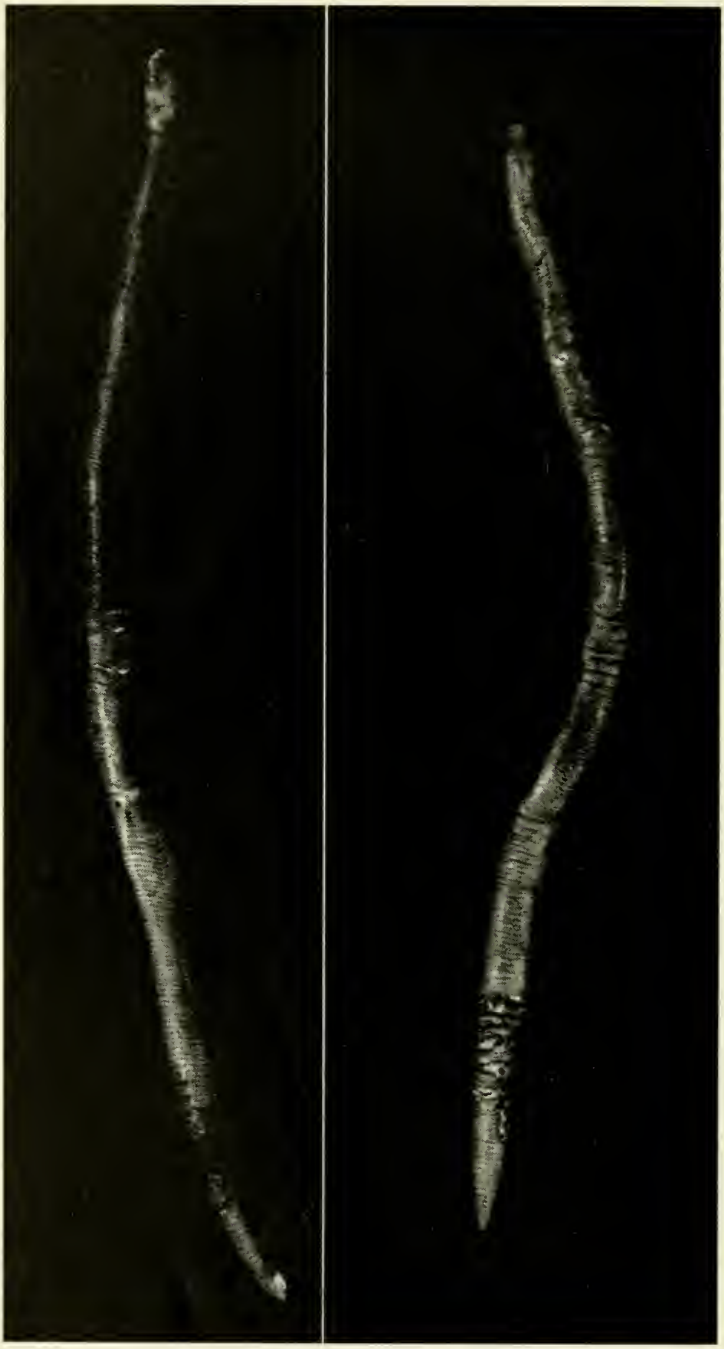

FIG. 3. *Ichthyophis monochrous* (Bleeker). Type. B. M. N. H. No. 63. 12.4.5. Sinkawang, west Borneo. Left figure, dorsal view; right figure, ventral view. Actual length of both figures, 232 mm.

forming a strongly marked angle on venter; a narrow cream-colored ring about eye, and a cream spot on vent; tail short, 3.8 mm., with six folds.

Redescription of type: A moderately slender species, the length 232 mm.; width about 10 mm.; the width in length, approximately

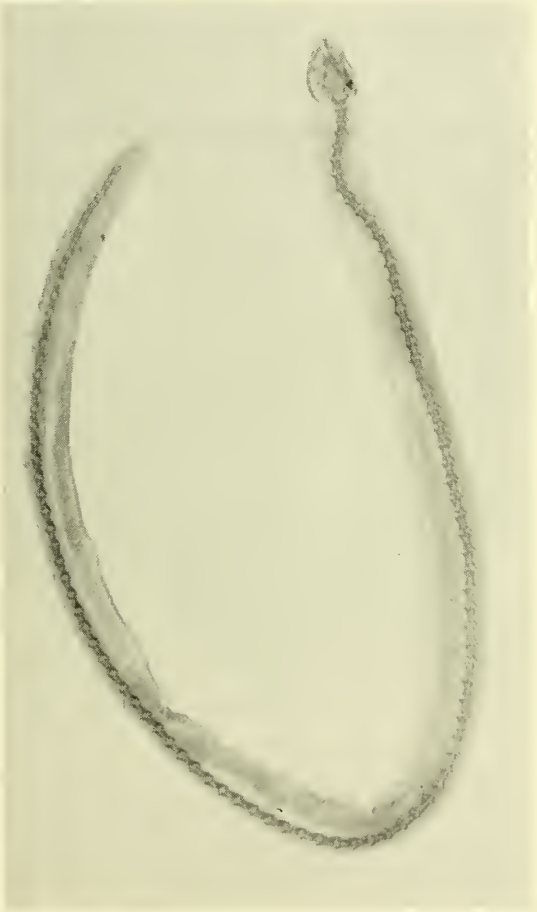

Fig. 4. *Ichthyophis monochrous* (Bleeker) Type. Radiograph showing 108 vertebrae

23 times; head oval in outline, the curved width between eyes, 6 mm.; width of head, 7 mm.; length of head, 9 mm.; snout length in front of eyes, 4.2 mm.; eye visible, its diameter .4 mm.; tentacle conical, situated near lip, closer to eye (1 mm.), than to nostril (2.5 mm.), the tentacular opening lunate; nostril to lip, 1.4 mm.; eye to lip, 1.15 mm.; length of head from first groove, 8.6 mm.; from

second groove to snout tip, 11.6 mm.; from third groove to snout tip, 14.8 mm. (measured on side); the first nuchal groove is strongly distinct on the throat, dim above; second groove strong on throat but not visible dorsally; third groove visible laterally, crossing above neck as a typical costal groove, not completely crossing throat below. This is preceded on dorsal surface by a short somewhat angular fold that terminates on the dorsal surface; the first four transverse folds (following the third nuchal groove) do not meet on venter; subsequent folds cross dorsum and sides in a sinuous line, then bend backwards and meet at an angle on venter, at a point four or more millimeters farther posterior than on dorsum. The primaries and secondaries (perhaps tertiaries)* cannot be ordinarily distinguished from each other.

There is a small but distinct tail bearing six transverse folds posterior to anterior edge of vent, its length about 3.8 mm.; an area about vent flattened; tail rounded above and somewhat compressed laterally, terminally pointed; no trace of elevated lateral longitudinal folds on body.

Skin strongly glandular throughout surface of body, and because of the folding most of the larger glands lie recumbent in the skin, very many having a length of more than one millimeter; each transverse fold overlaps somewhat the deeper following fold; concealed scales are present throughout surface of body, each fold covering from one to five rows of transversely overlapping scales which encircle the body; the preceding several rows of scales, though separated by tissue, actually overlap the anterior scale series of the following fold; scalerows of each fold imbricated, the anterior overlapping the posterior.

The largest scales measure 1.8 mm. in greatest diameter. The number of rows and the size of scales is reduced in the anterior part of body. The vent is longitudinal with lateral grooves forming a denticulate edge (some 8 denticles on each side); no gland is visible on sides of vent. Teeth: maxillary-premaxillary, 25-25; vomeropalatine, 21-21; mandibular, 19-19; splenial, 4-4. The tongue is broad, rounded, partially covering the splenial teeth.

Color in preservative for one hundred years: Dark brown above and on head, the edge of each fold distinctly lighter, nearly fawn-colored; eyes dark with whitish pupil surrounded by a narrow cream-colored ring; a cream-colored area about vent occupying

* Some previous authors have suggested that there are two transverse folds to each body segment in Caecilians. This is certainly not true in all cases, since the vertebrae of all specimens from S. E. Asia number less than half and often only a third of the number of transverse folds. Thus it must appear that numerous vertebrae have more than two transverse folds.

space between the interrupted folds; area about nostril dull cream; grooves on throat lighter than surrounding color. In life the color is said to have been violet-brown.

Measurements in mm.: Total length 226 (Bleeker's measurement 232) width of body, 10; width of head, 7; head length 9; largest scales, 2 mm. in diameter; width in body length approximately 22-23 times.*

Remarks: The specimen has been somewhat dehydrated and the back part of the body has had the folds loosened.

Ichthyophis singaporensis ** sp. nov.

Ichthyophis glutinosus, var. Cantor, Journ. Asiat. Soc. Bengal, vol. 16, p. 1058, and reprint in "Miscellaneous papers relating to Indo-China for Straits Branch of Royal Asiat. Soc.," vol. 2, Trubner and Co., London, 1886, p. ?; Boulenger, Catalogue of the Batrachia Gradientia *s.* Caudata and Batrachia Apoda in the Collection of the British Museum, 2nd ed., 1882, p. 91.

Type: British Museum No. RR. 1959.1, 2.43. Singapore. ***

Diagnosis: A small species having 267 primary and secondary folds about the body, 7 confined to short tail; maxillary-premaxillary teeth, 24-24; vomeropalatine, 20-20; mandibular, 20-20; splenial, 3-3. Orbit completely surrounded by bone; the tentacular opening in maxillary bone close to lip, nearer to eye than to nostril; separated from orbit by bone for a distance greater than the diameter of the opening. Total length of type, 243 mm. Tail length in total length 54 times; body width in total length 22 times. Vertebrae 111.

Description of type: (External characters of the head missing; its general characteristics and size may be derived from the skull measurements given). Tentacular opening near lip, closer to eye than to nostril; estimated head length, 10 mm.; estimated width of head, 7.5; first nuchal groove can be traced around head, most distinct below; second nuchal groove distinct below, not reaching dorsal surface of neck; third groove seemingly distinct dorsally and more or less distinct ventrally.

Scales present in first transverse folds, large, and in one or two continuous rows about body (except median point on venter). These continue throughout body, the rows growing more numerous in each fold until posteriorly there may be 7 or 8 rows in a single fold, the fold 3 to 3.2 mm. wide, the scales imbricating and overlapping laterally, as well as passing entirely around body. Many

* The partial dehydration of the specimen has changed the measurements.

** Singapore + ensis = place, locality, country.

*** The skin of the head had been loosened from about the skull to expose the skull while it was still attached to the vertebral column. The skull has now been placed in a small glass container attached to the type specimen.

FIG. 5. *Ichthyophis singaporensis* sp. nov. Type. Radiograph showing 111 vertebrae.

scales in posterior folds visible through the skin in this specimen (probably due to state of preservation); elongate recumbent glands opening between the folds. Transverse folds, dorsolateral count, 267, with 7 confined to tail; first three chevron-shaped folds on dorsum above pharynx occurring between the two posterior nuchal grooves, do not reach ventral part, but have well-developed scales; the fourth and succeeding folds completely surround the body, ventrally forming an angle, the transverse grooves seemingly not traceable on ventral parts until a short distance in front of vent where the folds and grooves cross venter without forming an angle;

vent longitudinal, interrupting four folds. Vertebrae 111. (Tooth formula in diagnosis.)

Color in preservative: Dull dark brown; if a cream spot occurs at vent it has now been discolored; a rather broad cream line borders the lower edge of each lower jaw, a darker line separating this from the lip; no cream spots discernible at eye, tentacle, or nostril.

Measurements in mm.: Total length (estimated for missing head based on skull length), 243; tail, 4.5; estimated width of head, 7.5; length of head, 10; body width, 11; width in length, 22 times; tail in total length, 54 times.

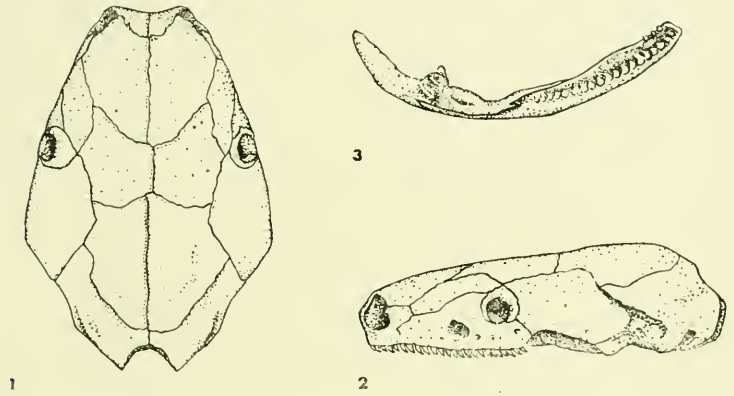

Fig. 6. *Ichthyophis singaporensis* sp. nov. Type. Fig. 1, dorsal view of skull; fig. 2, lateral view of skull; fig. 3, lower jaw, much enlarged.

Remarks: Figures of the skull show most of the important relations of the bones of the skull. One of the most significant features is that the orbit is closed completely and widely separated from the tentacular opening in the maxillary.

Figure 28,* *Epicrium glutinosum* given by Wiedersheim offering a lateral view of the skull shows the tentacular canal continuous with and forming a forward and downward extension of the orbital cavity. I am uncertain of the source of the specimen figured by Wiedersheim and cannot be certain that it even represents *glutinosus* as here considered. However it suggests the possibility that two genera are involved.

It is with some reluctance that I have used this ancient specimen, now badly mutilated, as a type specimen. The characters however, point to a distinct species. It came from a garden on Singapore

* Die Anatomie der Gymnophionen. Jena 1879, Plates: 2, fig. 23; 3, figs. 25, 26, 28, 29, 31; 4, figs. 35, 38 to 42, 43; 6, figs. 62, 69, 70; 7, figs. 75, 80; 9, fig. 88.

Island and to the best of my knowledge is the only specimen that has been reported as having been captured there despite the intervention of at least one hundred eleven years. I failed to find it during a stay of some weeks on the Island. If the specimen actually came from some other locality it is no less remarkable since it has not been reported elsewhere.

That the species may be related to *Ichthyophis monochrous* is shown in the body proportions, and the reduced splenial teeth. They differ however in the development of the scales, and the number of transverse folds is somewhat larger in *singaporensis*. The matter of relationships cannot be decided until the skull characters of *I. monochrous* are known.

Ichthyophis dulitensis * sp. nov.

Ichthyophis monochrous Boulenger, Proc. Zool. Soc., London, 1892, p. 508 (Mt. Dulit, Borneo).

Type: British Museum of Natural History, No. 92.6.3.23, Mount Dulit, Sarawak, Borneo; elevation above 2000 feet; collected by Mr. Charles Hose, autumn 1891.

Diagnosis: A mountain species, 235 mm. in length, having 114 vertebrae and 313 transverse folds; splenial teeth reduced (4-4); the body width in length about 29 times; head of lighter color than body; a large cream spot on chin and throat; pharyngeal region darker than body or head.

Description of the type: A moderately slender species, the width in length approximately 29 times; head width at first nuchal groove, 8 mm.; the length of head, 11 mm.; width between eyes, 5.15 mm.; length of snout in front of eyes, 4.2 mm.; eye small with a white pupil surrounded by a black iris, slightly elevated on surface of head, its diameter, .9 mm.; head length from snout-tip to first nuchal groove, 10.5 mm.; to second groove, 13.2 mm.; to third, 17 mm.; tentacle conical, the opening lunate, the area about opening swollen, closer to eye (1.5 mm.) than to nostril (2.5 mm.); nostril and eye about equidistant from lip, the distance between them 3.4 mm.; the first nuchal groove is distinct on throat and sides of head but very dim or absent on dorsal part; second groove distinct on throat and discernible on side of neck, but not on the dorsal region; the third groove can be discerned on the sides of neck only.

The primary and secondary transverse folds, 313 (dorsal count; 304 ventral count); all grooves and folds appear to pass completely around the body throughout the length, tending to turn backward

* (Mt.) Dulit + ensis (Latin) = place, locality, country.

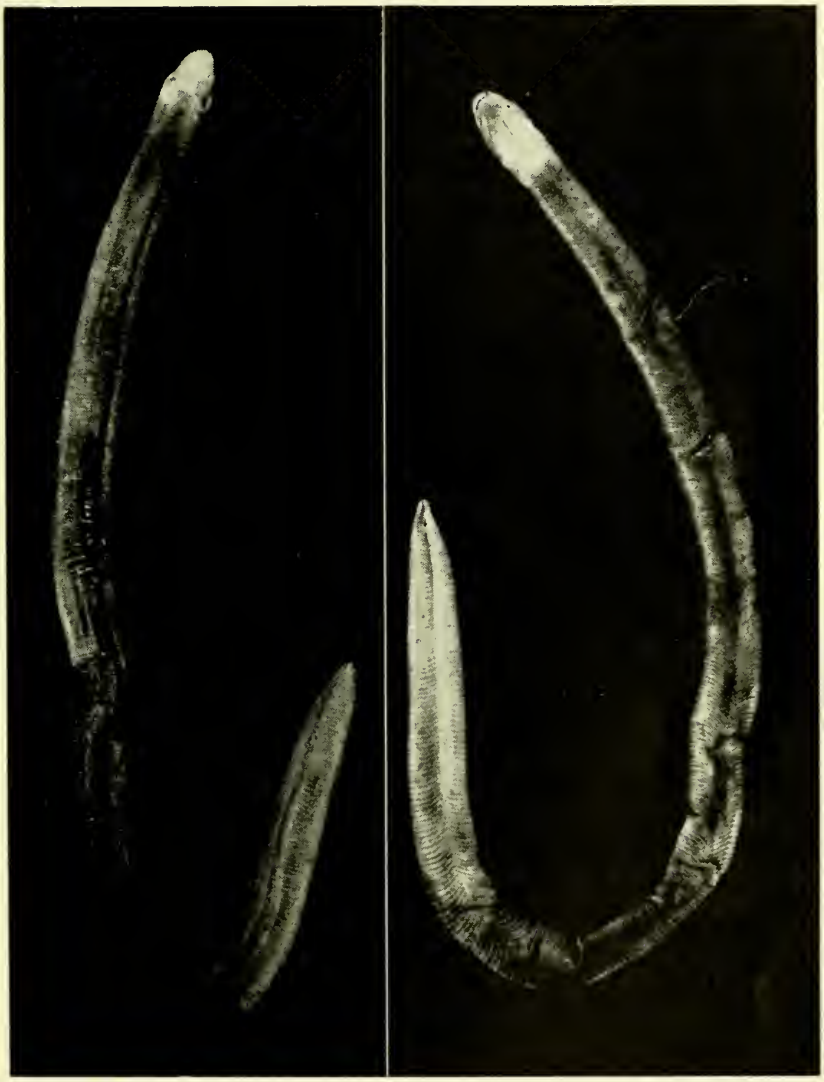

Fig. 7. *Ichthyophis dulitensis* sp. nov. Type. B. M. N. H. No. 92.6.3.23, Mt. Dulit, Sarawak, Borneo, elev. above 2000 ft. Left figure dorsal view, right figure, ventral view. Actual length, 235 mm. Note that the head of the left figure and the ventral side of the posterior part of the body are light struck. The white spot on the throat is natural.

and meet at an angle on ventral surface. The angles widen posteriorly and folds in front of vent pass almost directly across; seven folds on the tail (counted from front of vent); vent somewhat circular with a depression and groove following; a pair of tiny elevations on each side of vent suggesting glands.

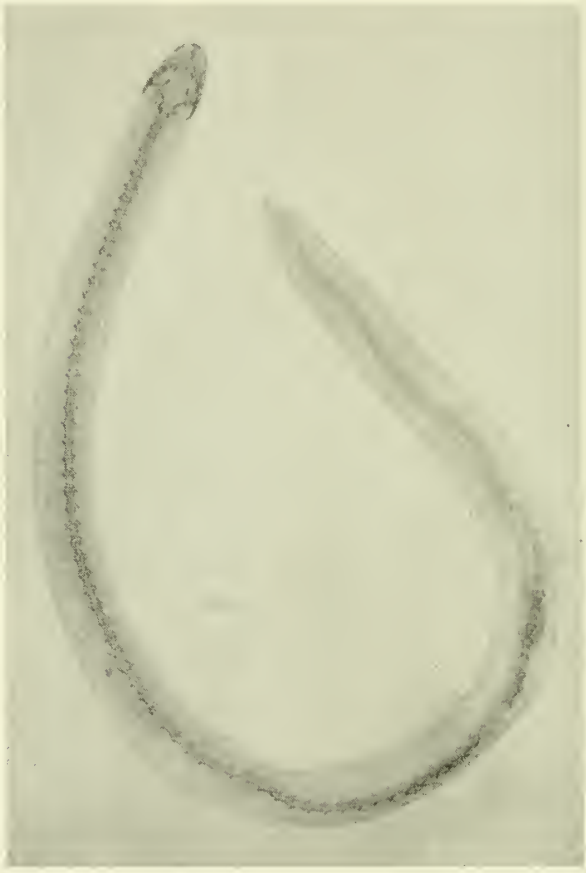

FIG. 8. *Ichthyophis dulitensis* sp. nov. Type. Radiograph showing 114 vertebrae.

Scales present throughout body, those on anterior part much reduced in number and size. In posterior part there may be as many as four or five rows of scales in each fold, which partially overlap the scales of the following fold.

Teeth: maxillary-premaxillary, 18-18; vomerpalatine, 23-23; mandibular, 20-20; splenial, 4-4.

The tongue is rounded, perhaps not covering the splenials completely; choanae rather large, the diameter of one (.76 mm.) in the space between them (2 mm.), 2.63 times; the tail length in total length, about 42 times.

Color in preservative: Head olive brown; pharyngeal region very dark black-brown contrasting with both body and head; brown generally over body, the front part of the transverse folds darker than the remainder so that fine lines of dark brown appear to be alternating with fine lines of tan; a cream spot surrounding the vent and the depression following; a cream spot about tentacle and nostril; a small cream ring about eye. The large cream spot on throat somewhat broken up by brownish lines in the nuchal grooves.

Measurements in mm.: Snout to vent, 235; tail, 5.6; head length, 11; head width, 8; average body width, 8.

Remarks: This species, which geographically is close to the type locality of *Ichthyophis monochrous* is clearly differentiated from the latter species by the much larger number of primary and secondary folds (313 instead of 247), the presence of a cream spot on the throat, seemingly a different type of vent, a larger head, and six more vertebrae.

They agree in having a reduced series of splenial teeth, and the body folds have the same type of ventral angle.

From *I. weberi* it differs in having a series of splenial teeth; from *I. javanicus* in being less slender, in having a reduced series of splenial teeth (4-4 instead of 12-12) and fewer transverse folds (313 instead of 351); from *I. glandulosus* in lacking the lateral ridges, in having folds and grooves encircle the body, more transverse folds (313 instead of 273), and a reduced series of splenial teeth.

Ichthyophis peninsularis * sp. nov.

Ichthyophis monochrous Boulenger, Catalogue of the Batrachia Gradientia *s.* Caudata and Batrachia Apoda in the Collection of the British Museum, 2nd Ed., 1882, p. 91, pl. 4, fig. 1 (*part.* Malabar); Fauna of British India, including Ceylon and Burma. Reptilia and Batrachia, 1890, p. 517 (*part.*); Ramaswami, Current Science, Bangalore, vol. 16, 1, 1947, pp. 8 to 10 (*? part.*).

Type: Brit. Mus. Nat. Hist., No. 82.12.12.6; Malabar, India, R. H. Beddome collector.

Diagnosis: A large species, with a broad, relatively short head; the eye invisible covered with a raised circular white spot; the tentacle nearer the eye-spot than to the rostril; tail long, its length

* Peninsula (Latin) referring to peninsular India.

FIG. 9. *Ichthyophis peninsularis* sp. nov. Type. B. M. N. H. No. 82.12.12.6, Malabar, India. Actual length, 330 mm.

in total length nearly 22 times; the body width in length about 22 tacle nearer the eye-spot than to the nostril; tail rather long, its length in total length nearly 22 times; the body width in length about 22 times; transverse folds on dorsum, 363; folds on tail, 18; vertebrae, 116; splenial teeth, 4-4. Ventral surface very light, probably cream colored in life; a well-defined cream spot at vent.

Fig. 10. *Ichthyophis peninsularis* sp. nov. Type. B. M. N. H. No. 82.12.12.6. Radiograph showing 116 vertebrae.

Description of type: Width of head (14.4 mm.) only a little less than length of head (16 mm.); distance between eye-spot, 7.1 mm. measured on the curve, greater than length of snout in front of eyes (6.1 mm.); tentacle withdrawn, the tentacular opening circular;

tentacle opens near lip between eye and nostril, closer to eye-spot (2.5 mm.) than to nostril (4 mm.); eye-spot and nostril equidistant from lip, the distance between them 5 mm. The anterior nuchal groove encircles the head; second fold well defined on neck, and somewhat on sides of neck; third fold more or less distinct except in the median ventral area; snout tip to first groove, 14 mm.; to second, 19 mm.; to third, 24 mm.; six anterior folds fail to meet below on the median line; the folds can be seen because of the distribution of the glands but the grooves themselves seemingly do not cross the venter except in the posterior part of the body; folds counted on dorsal surface, 363; on ventral surface, 363, forming an obtuse angle directed backwards except in the posterior part of body where they pass directly across; tail somewhat compressed laterally and pointed terminally; the vent interrupts eight folds; a total of 18 folds on tail from front of vent.

Scales are present throughout body, anteriorly somewhat smaller and sparse or absent ventrally; posteriorly there are from three to five transverse rows in each fold extending around the body; vertebrae, 116.

Teeth: maxillary-premaxillary, 24-25; vomeropalatine, 25-26; mandibular, 25-24; splenial, 4-4. The maxillary teeth are larger than the vomeropalatine series, but are somewhat smaller than the mandibular or at least the anterior ones.

Coloration in preservative: Above, grayish lavender growing lighter laterally and ventrally; underside with some pigment but light, perhaps cream-colored in life. Head somewhat grayish brown; the eye-spots whitish; small cream areas about tentacle and nostril.

Measurements in mm.: Total length, 330; tail, 15.2; width of body, 14.8; head width, 14.4; head length, 16.

Variation: A second specimen available agrees with the preceding in general; the following data are given for comparison: length, 258, tail, 11.8, width of body, 13, width in length, 20, head width, 11.8, head length, 14; transverse folds (dorsal) 366, tail folds, 18. Teeth; maxillary-premaxillary teeth, 20-20; vomeropalatine, 19-19; mandibular, 15-15; splenial, 3-4. The specimen is one recently collected and is darker than the preceding.

A Berlin specimen from Malabar is young, measuring 222 mm. in length. The transverse folds number 357, the vertebrae, 116, and the splenial teeth, 4-4. The specimen is light lavender to violet above; below, the chin and neck are cream-white, and the remainder

of the venter is dull cream. The head is lighter in color than the remainder of the dorsum.

Remarks: It is not impossible that the type is somewhat faded since it has been in preservatives considerably more than half a century. It is, however, in relatively good condition except that exploration of the mouth has injured the tongue and the skull is broken in the palatal area.

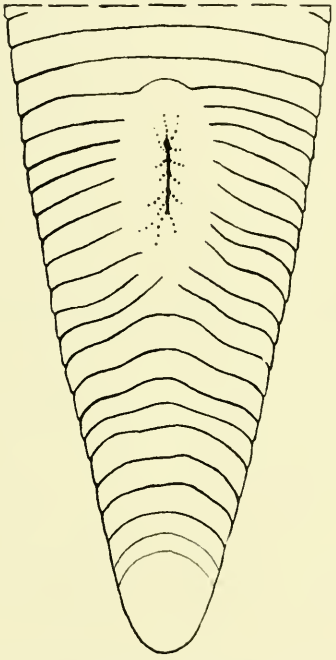

Fig. 11. *Ichthyophis peninsularis* sp. nov. Type. Characteristics of the subcaudal region. Enlarged.

Ichthyophis subterrestris * sp. nov.

Type: Chicago Natural History Museum No. 73927, Travancore-Cochin, plains, India.

Paratype: Stanford Mus. No. 2118, from Kottayam, Travancore, India.

Diagnosis: Dark violet-lavender above and dark lavender-brown venter; a light area about nostril, but not about tentacle or vent; tentacular opening circular; mandibular teeth very large, approximately three times the size of teeth in maxillary series; splenial

* Sub (Latin) under + terrestris (Latin) = of the earth.

teeth, 5-5; 364 folds, 18 on tail. Total length, 260; tail, 11.7; tail length in total length, 22.2 times; body width in body length approximately 21 times.

Description of type: Head somewhat elevated posteriorly, the width at first nuchal groove 11 mm.; the length of head, 14 mm.; distance between eyes on curve (6-8 mm.) greater than length of snout (5.35 mm.); tentacle withdrawn, not attached to the edge of opening; the tentacular opening close to lip, circular; tentacle close to lip, much closer to eye (1.8 mm.) than to nostril (3 mm.); distance between eye and nostril, 4.3 mm. Distance from tip of snout to first nuchal groove, 13 mm.; to second, 16.8 mm.; to third, 20.2 mm. (measurements made on side of head).

Primary and secondary folds together 364, of which 18 are on tail; these cross the body, and form angles ventrally, except posteriorly; first four or five failing to meet on throat, eight interrupted by vent; anterior folds curve forward across neck; the grooves are not complete on venter except in the posterior part of the body; small scales are present from the first fold, both dorsally and ventrally, only one or two scalerows usually present; farther back scales increase in size and number the posterior folds having four or five rows, the first row of each series smallest, the one preceding the last largest, all imbricating.

Teeth: maxillary-premaxillary, 21-21; vomeropalatine, 21-21; mandibular 17-17; splenial, 5-5. The size of the teeth is such that the tiny notch near the outer anterior face of the tooth can be seen. The tongue is large, completely covering the splenial teeth, the anterior part broadly arrow-shaped and somewhat elevated. It seems probable that some of the posterior splenial teeth are missing since the paratype has a somewhat larger number.

Tail laterally compressed, the terminal part without folds (true in practically all species); a pair of darker areas along side of vent perhaps representing the position of special glands; choanae somewhat angular on their inner face, separated from each other by a distance equal to three times the transverse diameter of one.

Color in preservative: Dark violet-lavender above, becoming brownish-lavender on venter; slightly lighter about eye; however, a few small rounded flecks, presumable glands are present close to eye; a dull cream area about nostril; area about vent lighter than surroundings (perhaps originally cream).

Measurements in mm.: Total length, 260; tail, 11.7; tail in total length, 22.2 times; body width, 12.4; head width, 11; head length, 14.

Remarks: The absence of calcium in the body was discovered on examining an X-ray picture of the specimen. There is no trace of the skeleton to be discerned. This absence is probably caused by the method of preservation. It is a relatively recent specimen and whatever the chemical, so effective in dissolving calcium, it seemingly has not affected the color and texture of the other tissues.

The paratype agrees with the type in very considerable detail except that the skeleton is intact and there are three more splenial teeth on each side. The characteristics of the scales and their distribution are those of the type. There are 356 folds, 16 on tail.

The maxillary-premaxillary teeth are about 27-27; the vomeropalatines, 25-28; the mandibular, 20-20; and splenials, 8-8. The length is 295 mm. The skin on one side of the head has been removed disclosing the orbit and the tentacular groove. The latter is completely separated from the orbit occurs in *singaporensis,* as is indicated in fig. 6. The shape of the tentacular opening is somewhat more rectangular. The increase in number of teeth may be due to age.

This species is seemingly distinguished from other species of the Indian Peninsula by the following combination of characters: the shape of the tentacular opening; the elongate tail with the high number of folds; the tail length being contained in total length only 22.2 times; the enlarged mandibular teeth. The color of the venter separates it from *peninsularis* and the body proportions seem to be somewhat different.

Ichthyophis bombayensis * sp. nov.

Type: British Mus. Nat. Hist. No. 86.6.11.1, Waghii Surrat, Bombay, India; Gleadon, collector.

Diagnosis: A large species (390 mm.) having 386 transverse folds, 14 confined to tail; splenial teeth 9-9; body width in length, 26 times; vertebrae, 121; color in preservative, dark brown above, somewhat lighter brown below; tail relatively long contained in total length about 25 times; tongue tending to cover the splenial teeth; mandibular teeth much larger than maxillary-premaxillary series; vomeropalatine teeth relatively small, scarcely extending through the thick gums.

Description of type: Head proportionally small, its width at first nuchal fold 10 mm., the length 15 mm.; eye distinct, the lens a pearly sphere surrounded by a narrow black rim of iris and these in turn surrounded by a light ring on skin wider above eye, very nar-

* Bombay + ensis = place, locality, country.

row below; tentacular opening somewhat rounded, the tentacle a fine slender cone seemingly not attached laterally to the opening; tentacular opening about half a millimeter from lip, closer to eye (2.3 mm.) than to nostril (4 mm.); eye from nostril, 5.5 mm.; eye from lip, 1.9 mm., nostril from lip, 1.8 mm.; distance between eyes (on curve), 8 mm.; length of snout, 7 mm.; distance between nostrils, 4 mm. First nuchal fold well visible above on sides and on underside of neck, preceded by a distinct strongly curving fold on back of head beginning above mouth angle, not visible on sides or

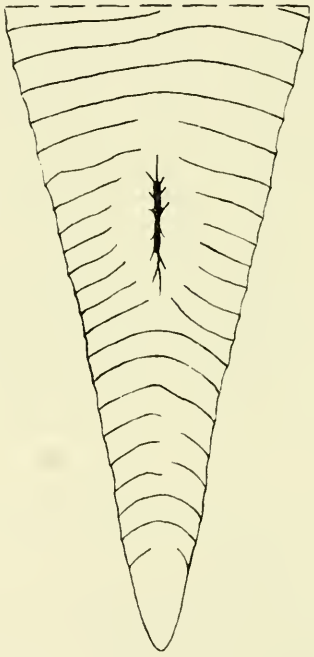

FIG. 12. *Ichthyophis bombayensis* sp. nov. Type. B. M. N. H. No. 86.6.11.1. Waghii Surrat, Bombay, India. Actual length, 390 mm.

below; second nuchal fold not discernible on sides or above, distinct below; third nuchal groove strong on sides, less so on dorsum, partly crossing venter. Snout to first nuchal groove (lateral measurement), 15 mm.; to second, 20 mm.; to third, 27 mm.

Transverse folds on body, 386; 13-14, folds confined to tail; tail rather strongly compressed laterally; transverse folds make a median forward curve dorsally, then on sides tend to turn back and form a median ventral angle at a point five to seven millimeters behind its most anterior point above. Scales are present throughout, anteriorly

usually only a single row in each fold, more posteriorly there may be three imbricating rows, the middle one much the largest in each fold.

Teeth: maxillary-premaxillary, 23-22; vomeropalatine, 24-24; mandibular, 20-20; splenial, 9-9.

Color in preservative: Above dark brown the posterior edge of the folds a little lighter; top of head somewhat mottled with darker brown; venter lighter brown; a cream spot surrounding vent. A small light area around eye; a cream spot below tentacle and one about nostril; lips and an area at mouth-angle cream.

Measurements in mm.: Total length, 390; tail, 15.2; head width, 10; head length, 15; width, 15; width in length, 26 times; tail length in total length, 25.6.

Remarks: The increased number of vertebrae, the coloration, the enlarged mandibular teeth and the reduction of the size of the vomeropalatine teeth seem to separate this from more southern Indian forms. The specimen is a male.

Ichthyophis mindanaoensis * sp. nov.

Ichthyophis monochrous Inger, Fieldiana Zool., vol. 33, no. 4, 1954, pp. 207-209 (*part.*); Todaya on Mount Apo, Davao Province, Mindanao, P. I.

Type: Chicago Natural History Museum No. 50958, Todaya, Mt. Apo, Davao, Mindanao, P. I., 2800 feet elevation, H. Hoogstral, collector.

Paratype: C. N. H. M. No. 50957, Mt. McKinley, Davao, Mindanao, P. I.

Diagnosis: A medium-sized species, largest known specimen, 276 mm. (283 fide Inger). Vertebrae, 110-116; transverse folds, 308-317; 322-341; body width in length approximately 28; tail length in total length approximately 43 times; splenial teeth, 8-8 to 11-11. Single gill opening on each side in larvae.

Transformation occurs in larvae after a length of 238 mm. has been reached, the large larvae retaining the lateral line system clearly defined on head. Differs from *glandulosus* (from Basilan, P. I.) in having 8 to 14 more vertebrae, more (30 or more than highest count) transverse folds. The choanal openings are at least one half larger.

Description of type: Head rounded, oval; snout projecting somewhat; eyes visible, covered with skin that forms a slightly raised circular area, dark in the middle and ringed with gray; width of

* Mindanao + ensis (Latin) = place, country of.

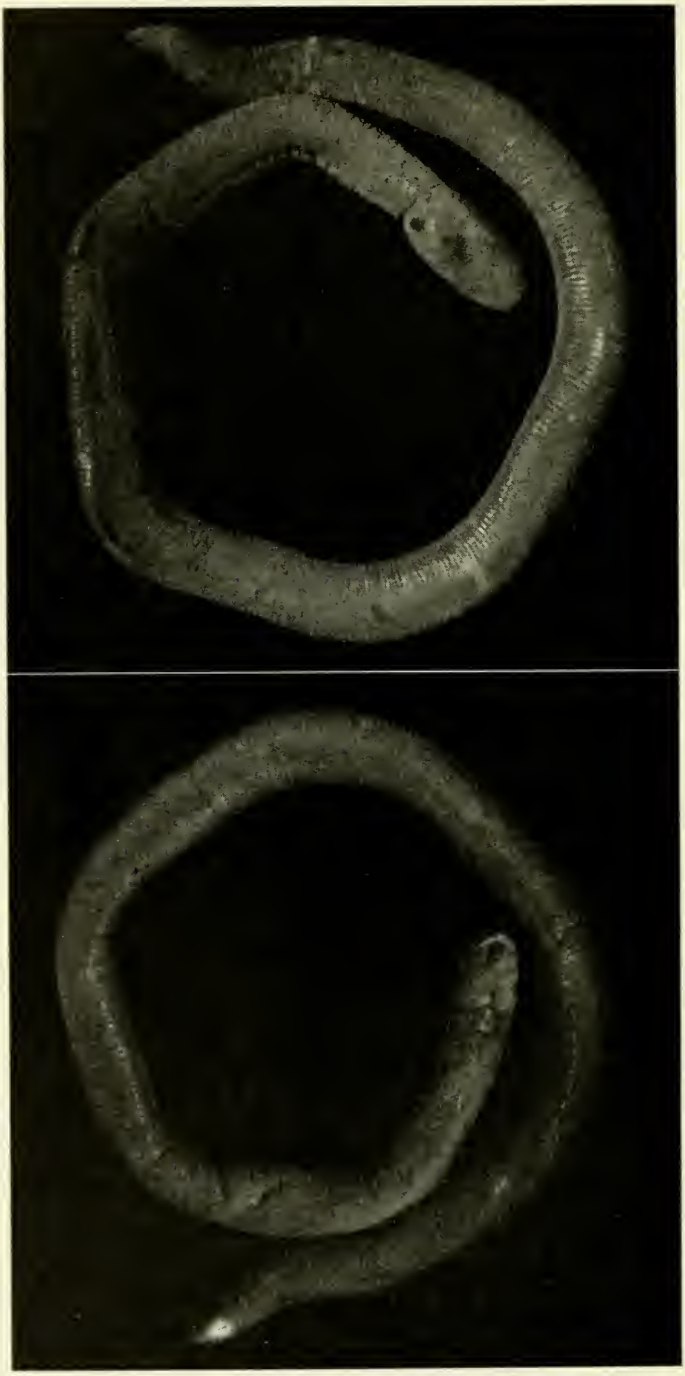

FIG. 13. *Ichthyophis mindanaoensis* sp. nov. Type. Chicago N. H. M. No. 50958. Todaya, Mt. Apo, Davao, Mindanao, P. I. 2800 ft. elev. Upper figure, dorsal view; lower figure, ventral view. Actual length, 276 mm.

head at first nuchal groove, 9.3 mm.; length of head, 14 mm.; tip of snout to first nuchal groove, 12 mm.; to second, 15 mm.; to third, 20 mm.; distance between eyes measured on curve (6 mm.) longer than snout (5.1 mm.); the first nuchal groove distinct on throat can be traced across top of head; second, distinct on throat and on side of neck for a short distance; third, visible across dorsum and on sides, scarcely or not discernible on throat. Tentacular opening lunate, near edge of lip, much closer to eye (1.5 mm.) than to nos-

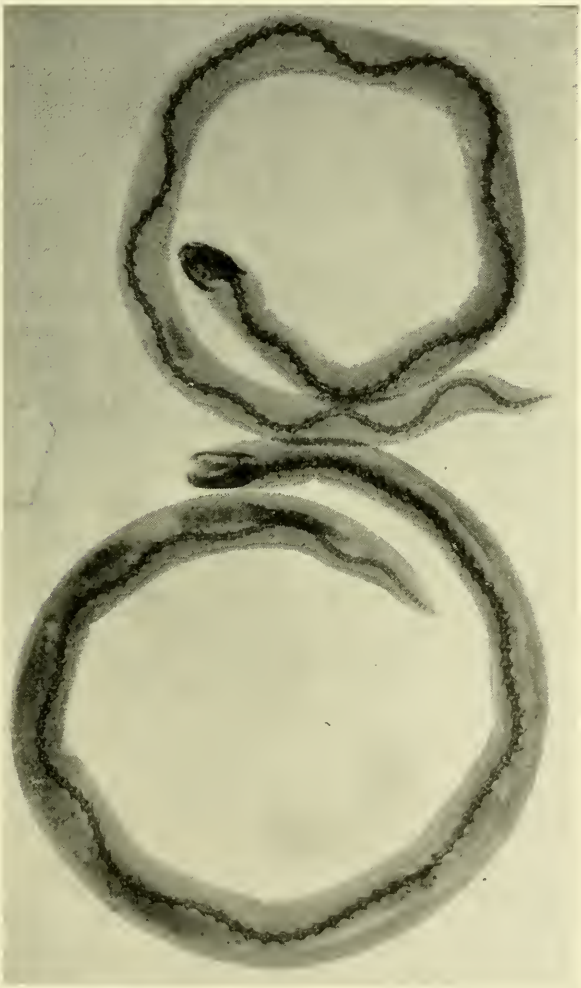

Fig. 14. *Ichthyophis mindanaoensis* sp. nov. Upper fig., type; lower fig., paratype. C. M. N. H. No. 50951, Mt. McKinley, Davao, Mindanao, P. I.

tril (3.6 mm.); distance between eye and nostril, 4.5 mm.; nostril closer to lip than eye. Transverse folds, 305, six confined to tail; folds and grooves complete across dorsum, the grooves failing to cross the middle part of venter except on the latter fourth or fifth of body. The vent interrupts three folds.

Choanal openings large, the distance between the edges of the choanae, 2 mm.

Scales present; anteriorly sparse, small, usually in a single row on dorsum in each fold; more posteriorly the scales increase in size and number until there are three or four rows surrounding the body in each fold. Vertebrae, 111.

Teeth: maxillary-premaxillary, 25-26; vomeropalatine, 24-24; mandibular, 17-18; splenial, 8-8.

Color in preservative: Above plumbeous-violet to brownish, the venter a slightly lighter shade; a cream spot covering vent, one about tentacle and one around nostril; a gray ring surrounds eye connecting with a gray area lying between eye and tentacle; some fine light areas under throat on midline. Lips lighter than sides of head; under clear liquid the body segments can be discerned along the median ventral line, as indicated by slightly darker transverse marks.

Measurements in mm.: Total length, 276; tail, 6.4; width of body approximately, 9.8; head width, 9.3; head length, 14.

Remarks: There is a second adult specimen in the collection from Mt. McKinley, Mindanao, P. I., taken at an elevation of 3000 feet, that may belong in this species. The specimen is 7 mm. longer than the type of *mindanaoensis* and has 113 vertebrae; there are 308 folds, 9 of which are confined to the tail. The scales are scattered, or absent and small when present on the anterior half of the body; at first only a single row present but in the posterior folds there are three rows, transversely overlapping, and imbricating.

Larvae: There is a series of larvae taken at Todaya, Mt. Apo, 2800 feet elevation, "to be found in rivers and on the ground during rain," that presumably represent this species. These specimens are recorded in the accompanying table.

The neuromast (lateral line) system is retained and is especially distinct in all but the largest larvae. It would appear that this is an adaptation for life in deeper waters such as rivers as opposed to brooks. In most of the species studied only the small and presumed very young larvae showed the organs clearly. The larvae are large at the time of transformation (238 mm.).

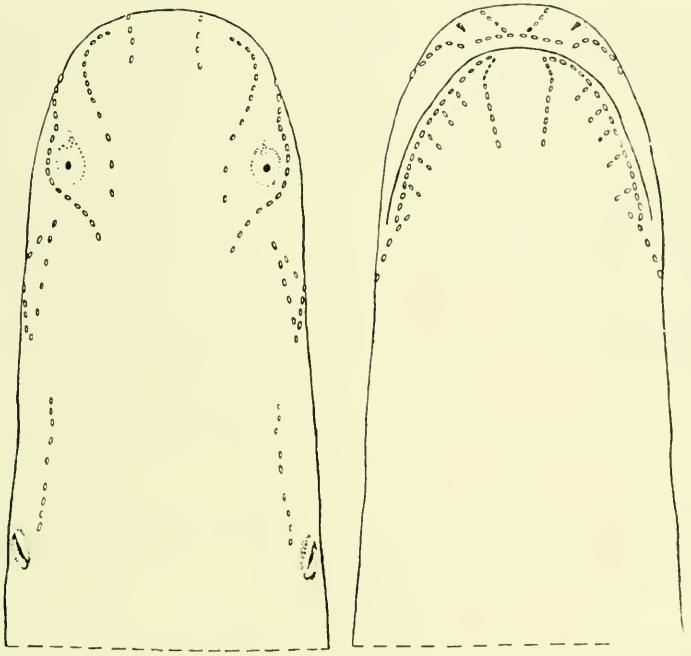

Fig. 15. *Ichthyophis mindanaoensis* sp. nov. Paratype larva. C. M. N. H. No. 50970, topotype. Actual length, 220 mm. Showing the details of the neuromast system in large larvae. Actual length, 220 mm.

Table of data on larval specimens presumed to be young of Ichthyophis mindanaoensis sp. nov.

Number	Length	Vertebrae	Body folds
50966	69		
50967	98		
50973	120		
50969	150		
50968	156		
50961	191		
50960	220	116	320
50970	220	116	327
50963	224	114	344
50964	231	114	330
50975	236	116	341
50971	236	116	324
50972	237	114	302
50976	238	114	334

Dr. Inger, with his characteristic graciousness, has kindly permitted me to study these adult specimens from Mindanao and the larval series which may be of the same species. Our findings are,

of course, quite different. I cannot agree that these specimens are conspecific with *Ichthyophis monochrous* Bleeker, *Ichthyophis glandulosus* Taylor and *Ichthyophis weberi* or with any one of them.

Dr. Inger's diagnosis of *I. monochrous* reads as follows: "Body cylindrical or slightly depressed, elongate; numerous annuli around the body; eye small, covered with skin; tail short, pointed; anal opening a longitudinal slit." A half or more of the known caecilians might easily fit this diagnosis and certainly the above mentioned species would thus be included in *Ichthyophis monochrous.*

His description is perhaps a composite made up from his specimens and from the literature since his variation in annular rings is somewhat greater than is shown in the Mindanao material.

Dr. Inger states that there is no tentacular aperture but he has overlooked this in the oldest larvae where a pit or aperture appears in the eye area; he also states that there are no spiracles, but these are certainly present in 14 of the larvae studied and are probably present in the entire 18 mentioned.

Ichthyophis glandulosus Taylor

Ichthyophis glandulosus Taylor, Philippine Journ. Sci., vol. 21, no. 3, Sept. 1922, pp. 516-517, pl. 3, figs. 4, 5 (type locality, Abung Abung, Basilan I., P. I.).

Ichthyophis monochrous Inger, Fieldiana Zool., vol. 33, no. 4, July 23, 1954 (*parts*).

Ichthyophis Taylor, Distribution of life in the Philippines, Bureau of Science, Monograph, no. 21, Manila, 1928, p. 219 (Zamboanga).

Diagnosis: A medium sized species (largest known specimen 250 mm.); 273 transverse folds and grooves, meeting on dorsum in neck region and in the latter two fifths of body, rarely meeting on venter except in latter part of body; inner mandibular splenial teeth 11-11; tongue somewhat pointed anteriorly rather than rounded; distinct dorsolateral ridges. Vertebrae, 102.

Redescription of type: Cal. Acad. Sci. No. 60073 Abung Abung, Cotobato, Mindanao, P. I. Moderately slender, the length, 250 mm., the width of body, 11 mm., the width in length about 23 times; eyes very dim, but visible, the distance between them (measured on the curve), 5.8 mm.; snout length in front of eyes, 4.5 mm.; width of head at first groove, 9.3 mm., length of head, 12.5 mm.; eye slightly elevated, its diameter, .95 mm.; tentacle not exserted, the opening vertically lunate, situated very close to edge of lip, 1.3 mm. from eye, and 3.5 mm. from nostril; nostril and eye each about 1.2 mm. from lip; tip of snout to first groove, 11.5 mm., to second, 15

mm., to third groove, 17.2 mm. (these three measurements are made on the side of head and neck).

First nuchal groove deeply marked on throat and on sides, less distinct dorsally and not, or but dimly crossing dorsal area; third groove distinct laterally but only faintly indicated on ventral and dorsal surfaces. Grooves following do not meet on the ventral part of body except the 22 preceding vent; the first 22 meet dorsally, and the terminal 70 grooves meet. The folds do not meet dorsally throughout much of body where grooves fail to meet (or their meeting not discernible); four folds interrupted by vent.

Scales present posteriorly, three or four rows of scales in each fold. Farther forward there may be only two rows of very small scales; and anteriorly they seem to be entirely absent in first 40 or 50 folds, perhaps more. When present scales of one fold tend to overlie partially those in the following fold, although separated by tissue.

There are 273 folds altogether, six on tail; posteriorly, where they can be seen to meet, they form a slight angle directed posteriorly; a pair of sharply defined lateral folds or ridges extend throughout body to within 2.5 centimeters of the tail tip.

Skin glands are present throughout the body and many can be seen through the skin; the largest ones seem to have their openings along the edges of the grooves and tend to lie recumbent in rows below the scales. There are two swollen areas on each side of the anterior part of the vent suggesting special glands. Vent longitudinal, the edges denticulate; the terminal part of tail lacking folds; sides of tail slightly compressed, the tip somewhat pointed.

Teeth: maxillary-premaxillary, 23-23; vomeropalatine, 24-24; mandibular, 21-21; splenial, 11-11. The tongue pointed rather than rounded, partially covering the splenial teeth; choanae small, the transverse diameter about .35 mm., contained into distance between them about 6 times.

Color in life: "Deep lavender to slate; more olive than lavender on venter. In formalin the specimen is brownish-lavender with scattered deep purple markings." After 38 years in alcohol the specimen brownish, with a slightly lighter brown venter, the purple marks indicated. A cream area around vent.

Measurements in mm.: Total length, 250; tail from front of vent, 6.2; head width, 9.3; head length, 12.5; width of body (average) about 11; width in length approximately 22.7 times.

FIG. 16. *Ichthyophis glandulosis* Taylor. Type. Cal. A. S. No. 60073, Abung Abung, Cotabato, Mindanao, P. I. Actual length, 250 mm.

Variation: There are three paratypes; one measuring 165 mm. was (in life) a deep slate-purple; the lateral folds are present in all. The posterior part of the head is less widened than in the adult.

The specimens were obtained under fallen logs in moist situations along a small forest stream in southern Basilan. The species can be separated from *Ichthyophis weberi* by the long series of splenial teeth (11-11), none in *weberi*, and the low number of folds about body (273 compared to 324 in *weberi*), and the fact that the grooves do not cross the dorsum throughout much of the body. From *monochrous* it may be separated, by the failure of the grooves to meet on the mid-ventral line in much of the body, in the longer series of splenial teeth and in the presumed greater number of body folds (273 compared to 247 in the type of *monochrous*), and fewer scales in each fold.

Remarks: A specimen of *Ichthyophis* was taken near the city of Zamboanga, in the Province of Zamboanga, Mindanao, Philippine Islands in 1923. I was unable to make a study of the specimen but it was tentatively identified as "*Ichthyophis* (?) *glandulosus* Taylor." On my return to Manila in 1957 I learned that this specimen as well as the type of *Ichthyophis weberi* had been destroyed in the final battle fought in Manila of World War II. A last stand was made by the Japanese in that section of the building where I formerly had my office and which housed the extensive herpetological and ichthyological collections. All collections were destroyed. There is no certainty that the species was *glandulosus*. The paratype material is not now available to me for study.

*Ichthyophis javanicus** sp. nov.

Type: British Museum of Natural History, No. 80.5.7.3. Collected, "Java" the exact locality not known.

Diagnosis: A slender species, the greatest known length, 210 mm., the body width, 6 mm.; the tail length, 4.5 mm.; width in length, 35 times; splenial teeth, 12-12; vertebrae, 115; primary and secondary transverse folds, 351 dorsal, —348 ventral count; ten folds on tail, five interrupted by longitudinal vent; tentacle nearer to eye than to nostril.

Description of type: A slender species the head slightly elevated, the height of head about 2.4 mm.; width between eyes, 4.5 mm.; length of snout anterior to eyes, 3.5 mm.; width of head at first nuchal groove, 6 mm.; length of head, 9.4 mm.; eye very distinct,

* Java + icus = belonging to, pertaining to.

the pupil white, the iris black with a very small cream area in front of eye; an incomplete ring of whitish flecks about eye; tentacle close to edge of lip, the tentacle conical seemingly somewhat rounded at tip, the tentacular opening lunate; tentacle nearer to eye (1 mm.) than to the nostril (2.3 mm.). First nuchal groove clearly indicated only on sides of head (or neck) but on throat vaguely indicated; second groove vaguely indicated on sides and

FIG. 17. *Ichthyophis javanicus* sp. nov. Type. B. M. N. H. No. 80.5.7.3. "Java." Actual length, 210 mm.

underside of neck; third groove no different in appearance from a primary costal groove; pharyngeal region not wider than head; tip of snout to first groove, 9 mm.; to second groove, 11.7 mm.; to third, 13.7 mm.

Approximately 351 primary and secondary folds surrounding body, meeting on the median ventral line at an angle which becomes broader posteriorly; ten folds on tail of which five are interrupted by vent; the transverse grooves likewise appear to surround the body; scales on anterior part of body absent or very small and scattered; posteriorly the scales form transverse rows, the scales overlapping, usually only one or two rows present

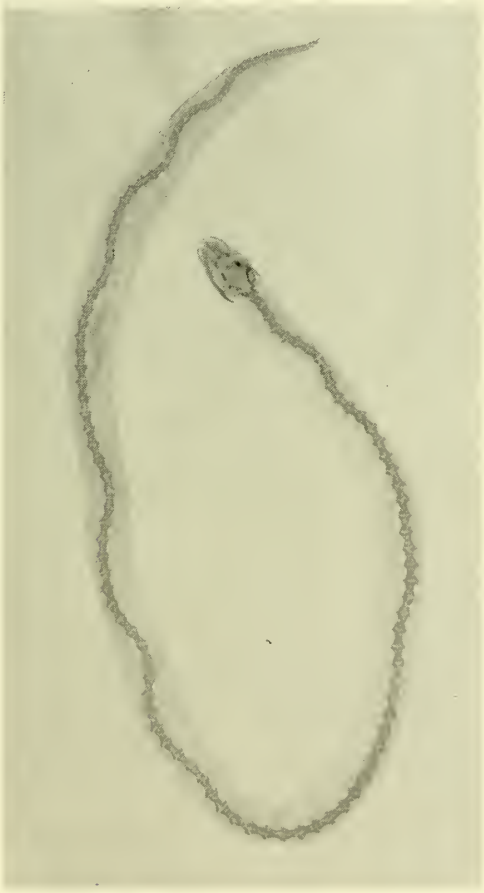

Fig. 18. *Ichthyophis javanicus* sp. nov. Type. Radiograph showing 115 vertebrae.

in each fold, the scales varying much in size. There are no dorsolateral ridges evident.

Teeth: maxillary-premaxillary, 19-19; vomeropalatine, 18-19; mandibular, 19-19; splenial, 12-12; the mandibular teeth largest, the splenials smallest; the tongue is somewhat narrowed anteriorly not covering the vomerine teeth.

Color in preservative: Entire body brown, the ventral surface only slightly lighter in shade; a cream-colored area about tentacle and nostril; a cream spot on vent widened anteriorly; the anterior edge of each fold slightly darker than remaining part.

Measurements in mm.: Total length, 210; tail length, 4.5; head width, 6; head length, 9.4; eye to nostril, 3.

Remarks: This species is easily differentiated from *Ichthyophis glandulosus* in having 78 more primary-secondary folds; from *I. monochrous* in having 104 more folds, and 115 rather than 108 vertebrae; from *I. weberi* in having a well-developed series of splenial teeth in the lower jaw (none in *weberi*). The specimen is attributed to "Janson" in the British Museum Catalogue.

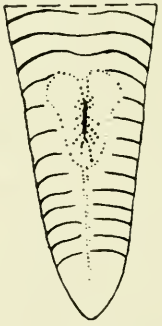

FIG. 19. *Ichthyophis javanicus* sp. nov. Type. Ventral view of caudal region; enlarged.

Ichthyophis malabarensis * sp. nov.

Type: Brit. Mus. Nat. Hist., No. 94.3.15.3, Maduvangard, Travancore, India; Ferguson, Collector.

Diagnosis: The largest oriental species known, reaching a length of about half a meter. Tail proportionately long, its length in total length 23.5 times; body width in total length about 27 times; transverse primary and secondary folds, 360, 14 on tail; vertebrae, 111; splenial tooth series, 10-10; other teeth numerous; tentacular open-

* Malabar + ensis, place locality of.

Fig. 20. *Ichthyophis malabarensis* sp. nov. Type. B. M. N. H. No. 94.3.15.3. Maduvangard, Travancore, India. Actual length, 494 mm.

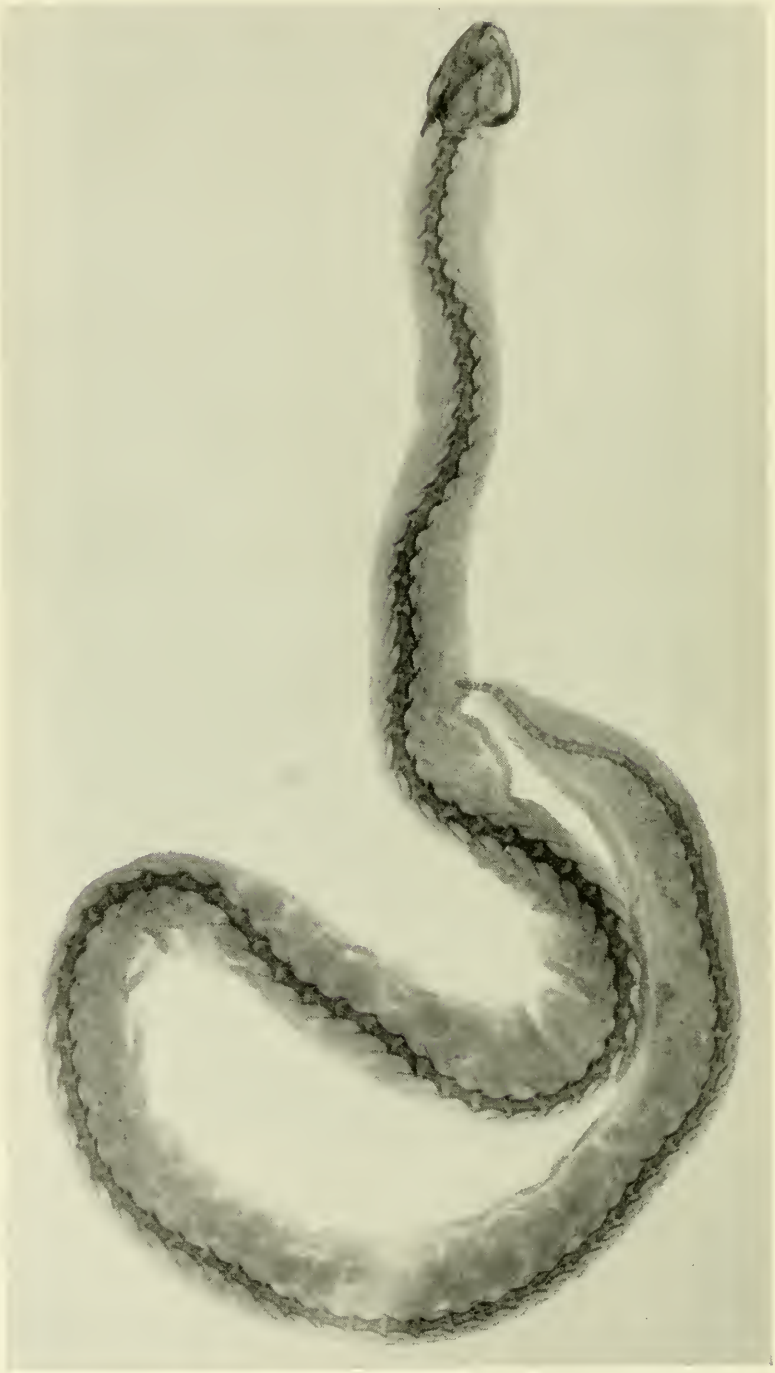

FIG. 21. *Ichthyophis malabarensis* sp. nov. Type. Radiograph showing 111 vertebrae.

ing close to edge of lip, nearer eye than to nostril; scales throughout body in four to five rows in each fold.

Description of type: Head broadly oval; the distance between the eyes (11 mm.) greater than length of snout in front of eyes (8.4 mm.); tentacle situated close to lip, closer to eye (2.6 mm.) than to nostril (5 mm.); distance between eye and nostril, 6.7 mm.; width of head at first transverse groove, 14 mm., the head length, 21 mm.; tip of snout to first groove, 19 mm.; to second, 26 mm.; to third, 32.3 mm.; two transverse folds appear anterior to the third nuchal groove that are incomplete; 360 primary and secondary folds encircle body forming on venter obtuse angles directed backwards, meeting on the mid-line except on posterior part of body where they pass straight across venter; on dorsal surface they are continuous, but anteriorly on the median line they tend to form a very obtuse angle, directed forward.

Scales are present throughout the body, those on anterior folds being small, sparse; posteriorly the scales increase in size and number of rows in each fold. Posteriorly the scales may measure 2.5 to 3 mm. in diameter. They tend to form four or five imbricating rows, the scales of one row overlapping laterally those of the same row. The series of one fold tend to overlie partially those of the following fold; vent longitudinal, interrupting six folds, which tend to bend forward on venter; no glands visible on region of vent; tail pointed, somewhat laterally compressed, with 14 folds, the terminal portion without folds.

Teeth: maxillary-premaxillary, 28-30; vomeropalatine, 30-28; mandibular, 28-28; splenial, 10-10; the maxillary-premaxillary teeth are larger than the vomeropalatine; the mandibular considerably larger than the maxillaries; the splenials distinctly smaller than the vomeropalatines.

Coloration in preservative: Dark brown dorsally, the anterior part of each fold darker than the posterior; laterally the color is lighter and becomes nearly cream on underside of body. Head above and on side, and anterior part of body somewhat mottled; a transparent ring around eye, showing the bony border of the orbit continuous; a cream spot on nostril; a small inconspicuous cream mark around vent.

Measurements in mm.: Total length, 494; tail, 21; body width (average), 18; head length, 20.2; head width, 14.5.

Remarks: It would appear that this species is rare in its range or that it burrows to a considerable distance below the surface of

the earth. A creature so conspicuous would otherwise be better known.

Despite the fact that it is the largest caecilian reported from Asia it has a relatively low number of vertebrae (111). The number of folds likewise is low when compared with certain other Indian forms treated here in this paper. The number of folds on the tail is 14, likewise a lower number than occurs in certain other Indian forms.

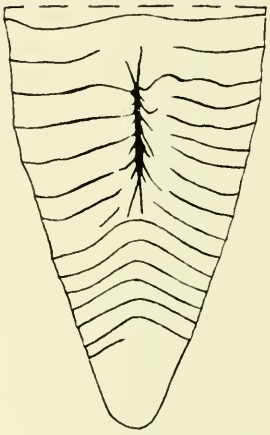

FIG. 22. *Ichthyophis malabarensis* sp. nov. Type. Ventral view of caudal region. Enlarged.

The specimen is a female containing many large eggs (5-6 mm. in diameter), the number estimated to be more than 60.

The figure of *Ichthyophis glutinosus* given in Wiedersheim (Die Anatomie der Gymnophionen. Taf. B, fig. 28) shows the orbit incomplete and continuous with the tentacular depression. It is probably impossible to determine the source of Wiedersheim's material. In this species the orbit is complete.* The mottled appearance, darker brownish marks on the anterior third of the body, is I believe a normal coloration and not due to preservation. The marks are more clearly evident when the specimen is submerged in a clear liquid.

Ichthyophis youngorum sp. nov.

Type: EHI-HMS No. 35946, Doi Suthep (Sutep), Chiang Mai, Thailand, at approximately 1200 m. in elevation; collected by Edward H. Taylor, July 12, 1957.

* The orbit is also complete in a specimen of *I. singaporensis* as well as perhaps in other species now placed in this genus. One may question whether these are congeneric with Wiedersheim's specimen.

Fig. 23. *Ichthyophis youngorum* sp. nov. Type. E. H. Taylor No. 35946, Doi Suthep, Chiang Mai, Thailand. 3900 ft. elev. Actual length, 210 mm.

Paratypes: EHI-HMS Nos. 35944 adult; Nos. 35932-35941 larvae all topotypes, July 12-15, 1957, same collector.

Diagnosis: A medium-sized species having large larvae (to 240 mm.); primary and secondary folds, 314-326; body width in length 16-17.5 times; splenial teeth, in adults to 12-12; largest adult seen, 220 mm. Scales absent in at least anterior third of body; reduced to a single overlapping row in each fold where present; vertebrae 106-107.

Description of type: A species of medium size, the body width in length 17.5 times; width of head, 9 mm., its length, 12 mm.; distance between eyes, 4.9 mm.; length of snout, 4.3 mm.; tentacle small, cone-shaped, the opening lunate, closer to eye (1.3 mm.) than to nostril (2.6 mm.).

First nuchal groove dimly visible on throat. Second groove visible on throat but reaching the level of the mouth on side; third groove barely indicated, not strong even laterally; a longitudinal groove on chin extending on to throat. Snout-tip to third groove, measured laterally, 16.5 mm.

The primary and secondary folds total 324 but many fail to reach venter. The count on side is 304, on venter 280; four folds interrupted by longitudinal vent; six folds on tail; a pair of dorsolateral ridges indicated; transverse folds meet on venter at a broad angle except posteriorly where they pass straight across venter. Scales absent anteriorly, present in latter two thirds of body; when they begin they are small, much wider than long; posteriorly they are larger, with a single overlapping row in each fold; vertebrae 107.

Teeth: maxillary-premaxillary, 21-22; vomeropalatine, 21-22; mandibular, 20-20; splenial, 12-12.

Color in life: General color above, violet to lavender; the venter lavender; the grooves (partly due to glands in the skin) appear light gray; chin blackish brown; head darker, nearly uniform plumbeous; a gray-white spot in front of eye more or less connected with a gray spot about tentacle; a slightly distinct light area about nostril; the edges of the vent are gray flesh with two small glands.

Measurements in mm.: Total length, 210; tail, 5.2; width of body, 12; width in length, 17.5 times; head length, 12; head width, 9; tail length in total length, about 40.4 times.

Variation: Another specimen, an adult topotypic paratype No. 35944 is almost an exact counterpart of the preceding specimen. It measures 220 mm. in length and the body width is contained in

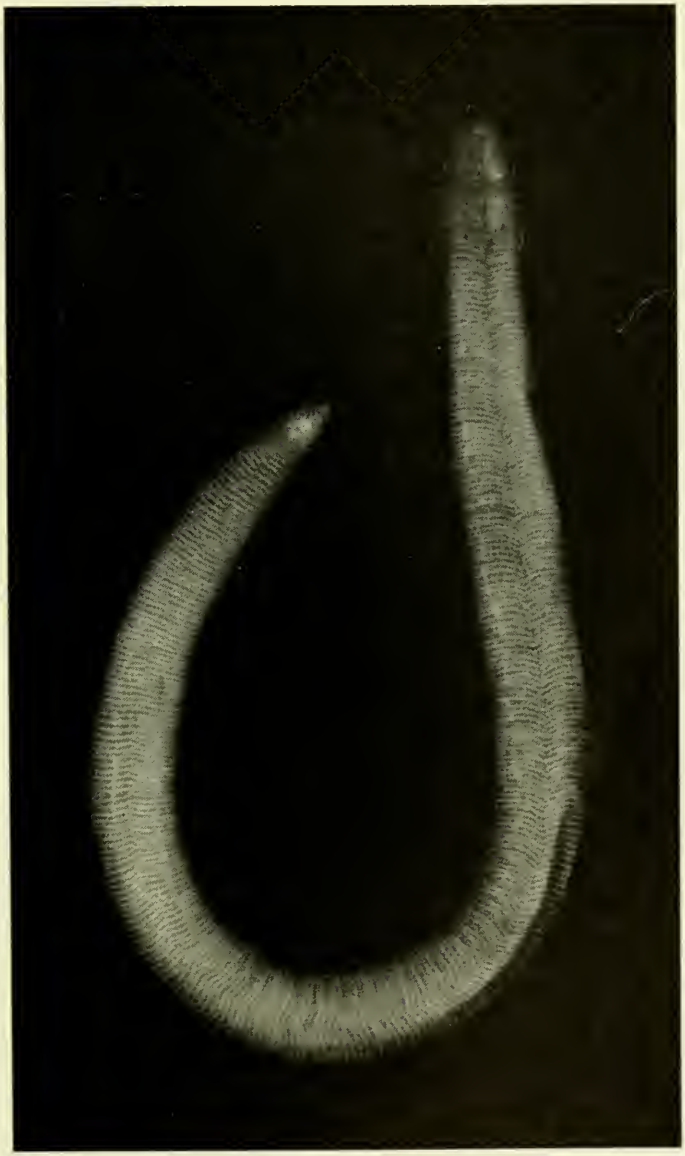

Fig. 24. *Ichthyophis youngorum* sp. nov. Type. E. H. T. No. 35946; ventral view. Actual length, 210 mm.

the length 18 times. The count of the transverse folds on the dorsum is 328, the lateral count, 292, the ventral count, 285; vertebrae 106.

The following table of data gives the size and other variations in a series of larva taken within a few meters of the adults. All are

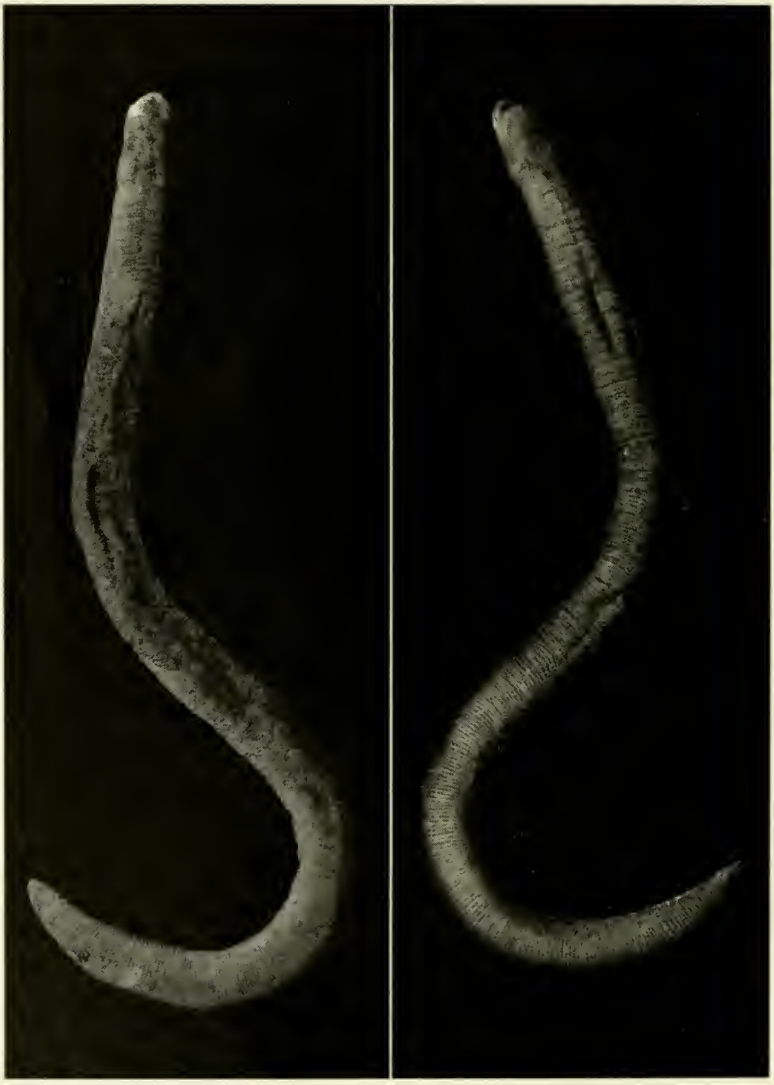

FIG. 25. *Ichthyophis youngorum* sp. nov. Paratype, larva; E. H. T. No. 35940. Topotype. Left figure, dorsal view; right figure, ventral view. Actual length, 217 mm.

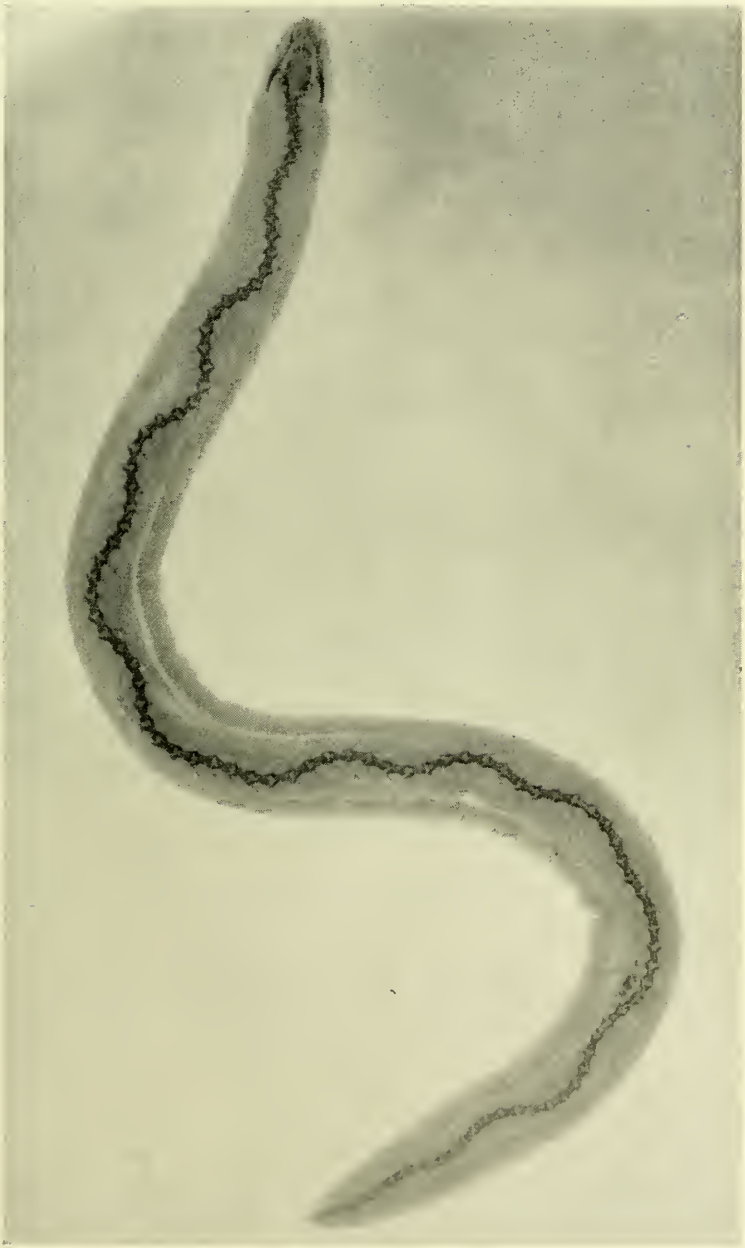

Fig. 26. *Ichthyophis youngorum* sp. nov. Larval paratype E. H. T. No. 35940. Radiograph showing 107 vertebrae. Actual length 217 mm.

from a mountain rivulet, the larvae having been taken from under rocks, trash or gravel in the stream bed.

The larvae have a single gill opening (spiracle) on each side flanked by two small fleshy lobes. The neuromast system is present on the head of the youngest larvae.

The eye is represented in the larvae by a gray spot and only rarely can the outlines of the pupil and iris be discerned. In young larvae the tentacular opening has not appeared; in older ones a depression may be found in the eye spot, and in the still older ones there is a tentacular opening, usually curved, in the gray eye-spot. The caudal fin is low and even in the youngest it can scarcely be traced

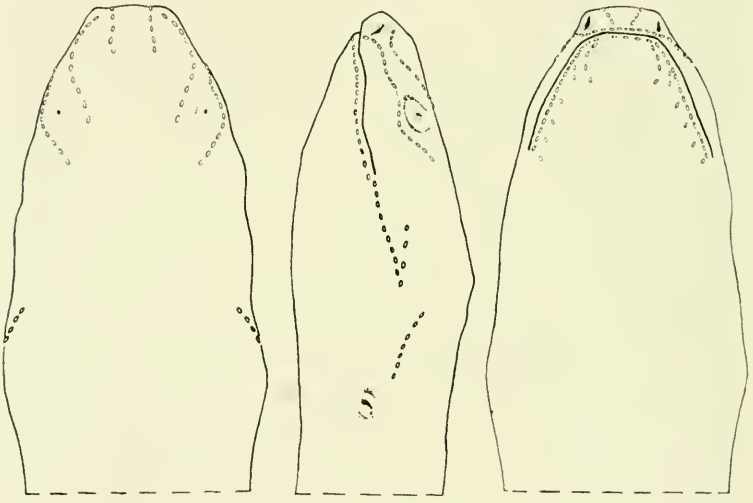

FIG. 27. *Ichthyophis youngorum* sp. nov. Larval paratype. E. H. T. No. 35949; topotype. Dorsal, lateral, and ventral views, showing the neuromast system of young larvae.

below the tail. In the older larvae the fin has completely disappeared. The young larvae are lighter in color than adults, while the older larvae may be a shade of ultramarine in color.

The largest larva 240 mm. has 106 vertebrae. Five larvae were X-rayed and the vertebrae were 106 or 107.

Specimens were kept alive for a time in shallow water. They were constantly moving when in the light. A slight noise could be heard when they were taken from the water, presumably caused by the water moving through the spiracle. No eggs were found.

This species is named for the family of Oliver Gordon Young of Chiang Mai, Thailand. Mr. Young has been untiring in his efforts to assist my work.

Table 2.—*Data on Ichthyophis youngorum sp. nov.*

Number	Length	Width	Width in length	Number	Length	Width	Width in length
35930....	75	5	15	35928....	119	6.3	18.8
35927....	80	5.2	16	35934....	127	7.5	16.9
35947....	80	5.2	16	35931....	142	8.7	16.4
35949....	81	5	16	35932....	147	9.2	16
35929....	84	5	17	35935....	162	9	18
35933....	85	5.2	16.4	35937....	184	10.2	18
35948....	86	5	17				

Number	Length	Width	Width in length	Dorsal count of folds	Ventral count	Max-premaxillary teeth	Vomeropalatine	Mandibular	Splenial
35936	194	11	17.6	325	280	14–14	18–18	18–18	12–12
35941	195	12	16.2	317	276	13–14	18–19	19–19	10–10
35942	213	12.5	17	314	302	16–16	16–18	19–19	10–10
35939	214	12.5	17.1	324	303	.....	.....	.....	.....
35938	214	12	18	320	284	14–14	16–17	19–19	9–9
35940	217	12.2	17.8	313	304	16–16	18–18	19–19	10–10
35943	217	12.2	17.7	316	283	16–16	19–19	19–20	10–10
35945	240	15	16	310	278	14–16	19–19	20–20	9–8

Ichthyophis sikkimensis * sp. nov.

Type: California Academy of Sciences, No. 64216, Darjeeling, India.

Paratypes: British Museum No. 87.11.2.28, Darjeeling, Bengal, India. Museum Comparative Zoology, No. 2685, Rungeet Valley, British Sikkim, Tom Barbour collector; Berlin Museum, No. 2574, Sikkim.

Diagnosis: A medium-sized species, characterized by 106-108 vertebrae; primary and secondary transverse folds 276-292; series of splenial teeth (9-9 or 10-10); tail very short, contained approximately 50 times in total length, bearing five or six folds from front of vent; tentacle near lip, closer to eye than to nostril. Scales sparse or absent in anterior half of body; two to four rows in each fold posteriorly.

* Sikkim + ensis (Latin) = place or country.

Description of type: A medium-sized species, largest known specimen, 276 mm. in total length; head slender, its width at first annular groove (10 mm.), less than length of head (11 mm.); eye closer to lip than nostril; tentacle very close to lip, nearer to eye (1.7 mm.) than to nostril (2.9 mm.); distance between eyes (6.1 mm.) greater than length of snout (5.2 mm.).

First annular groove distinct laterally, dim on throat, not completely crossing head; second groove crosses throat passing up on sides of head but a short distance; third groove distinct laterally not completely crossing neck either above or below; first two or

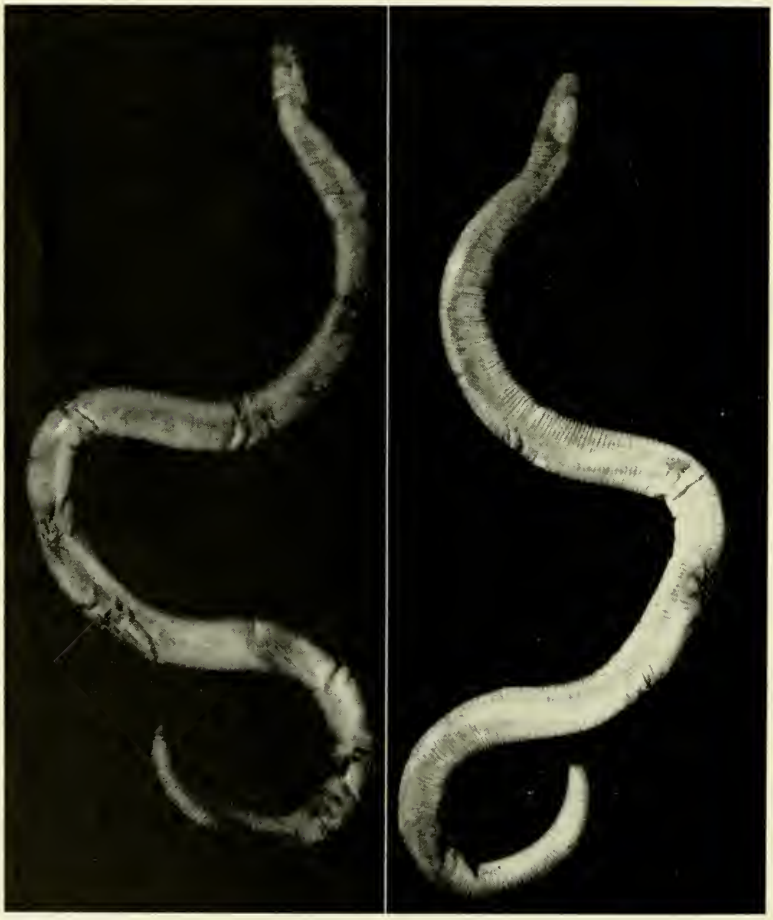

FIG. 28. *Ichthyophis sikkimensis* sp. nov. Paratype. Berlin Mus. No 3574. Left figure, dorsal view; right figure, ventral view. Actual length, 270 mm.

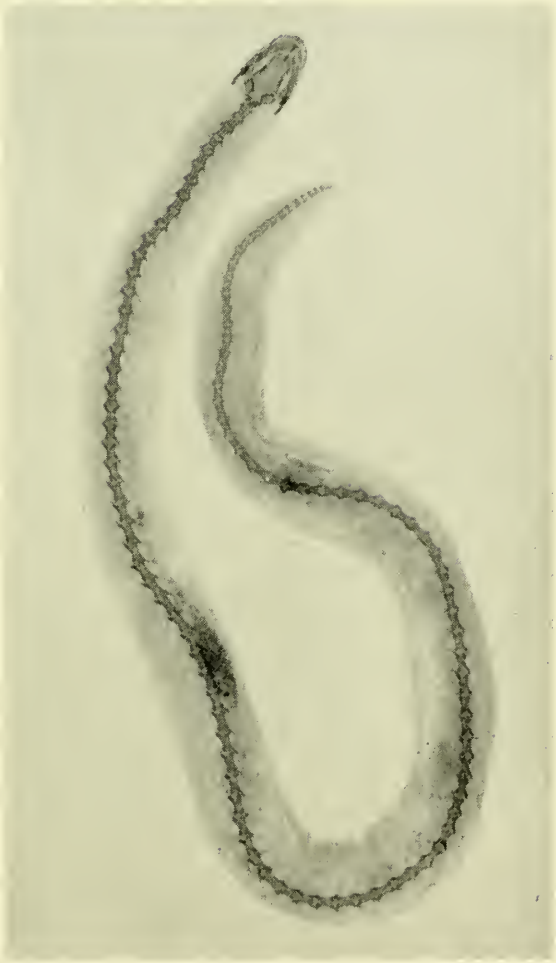

Fig. 29. *Ichthyophis sikkimensis* sp. nov. Paratype. B. M. N. H. No. 87.11.2.28. Radiograph showing 108 vertebrae.

three transverse folds not meeting below; primary and secondary folds forming a slight median ventral angle, the grooves not meeting on venter except posteriorly; (ordinarily, unless the specimen is somewhat dessicated the meeting of the folds on venter can be seen only dimly or not at all); total primary and secondary folds, 284, four of the posterior ones interrupted by vent; six folds on tail counting from front edge of vent; tail-tip rather conical; a slight longitudinal groove or depression on chin and throat.

Teeth: maxillary-premaxillary, 23-23; vomeropalatine, 21-21; mandibular, 20-21; splenial, 10-10.

A pair of small pimples (glands) on each side of vent.

Color: The specimen has been long preserved. The color is dark brown (a little lighter on the ventral surfaces). The underside of chin still lighter, while the grooves on chin and neck are marked dimly with cream; a more or less distinct cream tip on tail; a narrow cream ring about eye; a small cream spot about nostril and tentacle; the lips and tip of snout very light tan to cream.

Measurements in mm.: Total length, 276; tail, 5.5; width of body, 12.2; head width, 10; head length, 11.

Variation: No. 2685 has the pharyngeal region considerably thickened and widened. The eye is milky white, the pupil not visible. The tongue seemingly is not completely developed. It is very short covering the splenial teeth, and its posterior limit is a

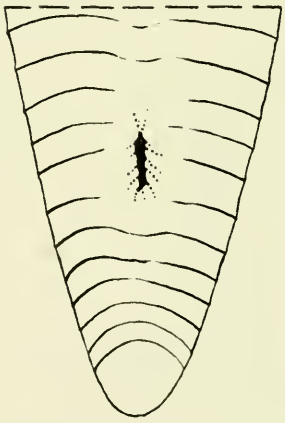

FIG. 30. *Ichthyophis sikkimensis* sp. nov. Type. Ventral view of caudal region. Enlarged.

ridge curving forward. This specimen agrees reasonably well with the others in tooth counts, vertebrae and transverse folds. It is, judging from the tongue, a recently transformed specimen that has not attained all the adult characters.

No. 3574, the other Sikkim specimen, is very light, almost white, on the venter and nearly white on chin. I cannot be certain that this specimen has not been faded somewhat by light.

The two Darjeeling specimens vary but little from each other.

Nothing is known of the exact habitats except that No. 2685 comes from the Rungeet Valley.

Data on type and paratype of Ichthyophis sikkimensis

Number	Total length	Tail	Body width	Transverse folds	Vertebrae	Width in length	Maxprenaxillary	Vomeropalatine	Mandibular	Splenial
64216.....	276	5.5	12.2	284	.....	22.6	23-23	21-21	20-21	10-10
87.11.2.28	263	5.4	12	292	108	22	23-23	21-21	20-21	10-10
2685.....	271	4.5	10	282	106	27	23-23	20-20	21-21	9-9
3574.....	270	4.5	10	276	107	27	23-23	21-21	18-19	9-9

*Ichthyophis sumatranus** sp. nov.

Type: U. S. Natural Museum No. 70672, Kapahiang, Sumatra; H. C. Kellars, collector.

Paratypes: U. S. N. M. Nos. 70667, 70669, Kaba Wetan, Sumatra; 70670, Kapahiang, Sumatra; all collected by H. C. Kellars.

Diagnosis: A medium-sized species characterized by an elongate series of splenial teeth, in adults 10-10 to 13-13; vertebrae, 110-112; transverse folds, females, 328-329; males, 315-318; tail in total length in larger adults about 54-57 times; body width in total length, average about 28 times; a semicircular row of small cream glandules partly surrounding eye; largest specimen, 285 mm. in length.

Description of type: Eye distinct, the lens appearing white, surrounded by a black iris; a small whitish spot in front of eye; a continuous semicircular row of tiny glandules run up from behind eye, then forward, terminating in the light mark in front of eye, (right eye abnormal); tentacle somewhat rounded at tip rather than conical, the tentacular opening lunate, curving above tentacle, opening close to lip at a point closer to eye (1.7 mm.) than to nostril (2.8 mm.); distance between eyes measured on a curve, 5.5 mm.; length of snout, 4.4 mm.; distance between nostril and eye, 4 mm.; tip of snout to first nuchal groove, 11.3 mm.; to second, 14.6; to third, 18.5; first groove not visible above, moderately distinct ventrally; second very distinct ventrally, slightly so on side of neck; third only indicated laterally.

* Sumatra + anus (Latin) = place, location, country.

FIG. 31. *Ichthyophis sumatranus* sp. nov. Type. U. S. N. M. No. 70672. Kapahiang, Sumatra. Actual length, 273 mm.

The first four or five transverse folds do not meet on venter; other folds cross back almost directly, curve back ventrally and form a median ventral angle, three to four millimeters behind the point where they crossed above; in the posterior part, the folds pass around body in about the same plane without forming an angle; vent interrupts five or six folds; total transverse folds, dorsal count, 315; 7 folds on tail; the transverse grooves rather dim (the specimen has been dehydrated slightly) and in places cannot be clearly discerned. They are distinct on sides and in the posterior part of body. The specimen is a male.

Small scales present anteriorly but sparse on dorsal and ventral parts of folds; more posteriorly they increase in size and number until there are three to five transverse imbricating rows passing around the body in each fold, partially overlapping the series of scales of the following fold, but separated from them by a row of recumbent glands lying nearly longitudinally.

Teeth: maxillary-premaxillary, 22-21; vomeropalatine, 22-21; mandibular, 20-19; splenial, 13-13. Vertebrae 112.

Color in preservative: Above dark brown, the grooves slightly lighter; ventral coloration a lighter shade of brown; a cream mark at vent, and at tip of tail; a tiny spot of white in front of eye and a fine semicircular row of cream-colored glandules partly surrounding eye; a cream spot at tentacle and nostril; edge of lips cream.

Measurements in mm.: Total length, 273; tail, 5; body width, 10; head length, 10.5; head width, 8.6.

Remarks: There are three paratypes, one a topotype from Kapahiang, a female, and two from Kaba Wetan.

No. 70667 the smallest specimen has had the internal organs removed. Where sex has been determined females have the higher count of transverse folds. The series is too small to postulate that this is generally true. This specimen has the eye-area milky white, the eye being distinguished with difficulty. In consequence the semicircular series of glandules cannot be seen. The specimen is violet-plumbeous in color. These seeming differences from the type may be due to age and method of preservation.

No. 70672 has the head somewhat lighter than body. The tip of the snout is somewhat cream-colored. This specimen shows a lighter line along the grooves, a character not or less evident in the smaller specimens.

The following table presents characters of these specimens.

Table of data from paratypes of Ichthyophis sumatranus

NUMBER	Length	Tail	Body width	Width in length	Head width	Head length
70669	285	5	9.5	30	9	11.5
70672	273	5	10	27.3	8.6	10.5
70667	205	3.5	8	25.5	7.2	10.1
70670	176	3.2	6	30	6	9

NUMBER	Vertebrae	Body folds	Tail folds	Max-premax.	Vomero-palatine	Mandibular	Splenial
70669	112	329	7	21–21	21–21	23–22	12–13
70672	112	315	7	22–21	22–21	20–19	13–13
70667	110	328	7	22–22	19–19	20–20	12–13
70670	110	318	7	20–21	24–23	18–19	10–10

*Ichthyophis acuminatus** sp. nov.

Type: American Museum of Natural History, No. 20875, Me Wang Valley, Thailand, Malcolm Smith, collector.

Paratypes: British Museum (Natural History), No. 1921.4.1.338, Me Wang, N. Thailand (field No. M. S. 3135); Malcolm Smith field Nos. 5656 Muang Liep, Thailand, and 3185, 3187 Pa Meang, Me Wang, Thailand.

Diagnosis: Large (about 300 mm.); head rather acuminate; eyes visible, very small; tentacle near lip, twice as close to eye as to nostril; splenial teeth, in transformed specimens, 15-15 to 22-22 in old adults; tail short, without cream spot about vent. Scales present in posterior part of body, wanting or greatly reduced anteriorly; body width in body length (in adults) about 20 times; transverse body folds on dorsum, 315-330, on venter, 297-320; vertebrae, 109-110. Larvae transform at a length of about 205 mm. Tail length in total length, approximately 43 times.

Description of type: Body thick, short, with dorsolateral ridges evident along sides; head acuminate, and, seen from above, forming a triangle; eye visible, minute (.7 mm.); tentacle close to lip,

* acuminatus (Latin) = pointed, referring to the snout.

Fig. 32. *Ichthyophis acuminatus* sp. nov. Type. A. M. N. H. No. 20875. Me Wang Valley, Thailand. Actual length, 295 mm.

minute, conical, the opening somewhat horseshoe-shaped, closer to eye (1.7 mm.) than to nostril (3.8 mm.); width between eyes, 7.8 mm. (measured on curve); length of snout, 5.8 mm.; tip of snout extending beyond mouth, 1 mm.; width of head, 11.6 mm.; length of head, 14 mm.; first annular groove well defined on sides of head and under chin; second groove ventral, ascending on side of head slightly, separated from preceding groove by a distance of 4 mm.; third groove scarcely indicated; first primary fold does not cross throat; all subsequent primaries and secondaries practically complete ventrally; the anterior folds are dim or incomplete dorsally on anterior fifth or sixth of body; the folds slightly angled on venter, while elsewhere they pass nearly straight across body; 315 primary and secondary folds, counted dorsally; 303 counted on venter; six confined to tail. Tail length in total length approximately 43 times.

Scales present in posterior two thirds of body, one or two rows to each fold; if present anteriorly scales much reduced, not extending on to venter and usually the scales in each transverse row are not contiguous; vent longitudinal, interrupting six folds; tip of tail pointed, flat on ventral surface, somewhat compressed laterally.

Teeth: maxillary-premaxillary series, 24-25; vomeropalatine, 26-27; mandibular, 25-24; splenial, 22-22 much smaller than other teeth. Tongue rather pointed, not covering the large series of splenial teeth. Vertebrae, 110.

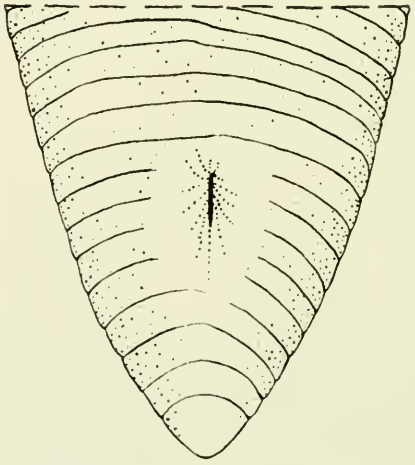

FIG. 33. *Ichthyophis acuminatus* sp. nov. Type. Ventral view of caudal region. Enlarged

Color in preservative: Somewhat violet-lavender, nearly uniform above, tending to be slightly lighter on throat and chin; area about vent somewhat lighter but not cream; area about tentacular opening cream; lips light flesh to cream.

Measurements in mm.: Total length, 295; tail, 7 (from front of vent); head width, 11.6; head length, 14; body width, 14.6; body width in length, 20.2 times.

Variation: There are two other transformed specimens from the Me Wang Valley in northern Thailand and a small series of larvae that most probably belong to this species. The larvae are listed with the adults in the following table, showing comparative measurements. The most significant variation (in teeth and folds) are given. The difference in count on dorsum and on venter is such that both counts are given. A lateral count is not likely to be either higher or lower than these counts. The counts of teeth and folds in the younger larvae are not trustworthy, hence are not recorded in the table.

Ichthyophis nigroflavus * sp. nov.

Type: U. S. N. M. No. 129462 "within 20 miles of Kuala Lumpur," Selangor, Malaya; Traub and Tipton collectors.

Diagnosis: A large species (425 mm.) the width contained in length about 26.5 times; body folds, dorsal count, 416 (ventral 399); folds on tail 7-8; vertebrae 123; maxillary teeth, 31-32; vomeropalatine 32-33; mandibular, 28-29; splenial, 0-0. Black above and below, a yellow lateral stripe beginning under eye narrow at first, widening posterior to pharynx; eye, tentacle and nostril with gray-white rings or spots (not cream).

Description of type: Head oval anteriorly, the sides nearly parallel, its width at first nuchal groove 10.7; head length, 12.8; eyes distinct, the lens white surrounded by a very narrow line of black (iris); these surrounded by a complete ring of gray-white; the distance between eyes, measured on the curve (8.5 mm.), greater than snout length (6 mm.); eye and nostril equidistant from lip, the distance between them, 4.9 mm.; tentacle conical the opening lunate, situated closer to eye (1.5 mm.) than to the nostril (3.8 mm.); tip of snout extends beyond nostril 1 mm.; tip of snout to first nuchal groove, 14 mm.; to second, 18.2 mm.; to third, 22.2 mm.

Dorsal count of primary and secondary folds (they cannot be distinguished), 416; counted on venter, 399; folds on tail, 8; scales

* nigro (Latin) = black + flavus (Latin) = yellow

Table of variation in I. acuminatus

AGE	Number	Body length	Body width	Width in length	Dorsal folds	Ventral folds	Vertebrae	Max-premax.	Vomero-palatine	Mandibular	Splenial
Larva	3189	151	6.8	22							
Larva	3188	152	8	19							
Larva	3184	175	8.1	21.6							
Larva	3796	174	7.9	22							
Adult	1921.4.1.338	205	10	20.5	315	297	110	22–22	22–22	22–23	13–14
Adult	5656	205	9	23	332	320	109	24–24	24–24	25–25	15–15
Larva	5701	205	10	20.5	331	322	110	16–17	23–23	20–22	11–12
Type	20875	295	14.6	20	315	303	110	23–25	26–27	25–24	22–22

are absent or if present minute on anterior sixth of length; more posteriorly they increase in number and size and in the posterior part of the body there are four or five transverse overlapping imbricating rows in each fold. There are 123 vertebrae. First nuchal groove surrounds head; second not visible above; third distinct laterally but can be traced across throat.

There are no splenial teeth, but in the other series the number of teeth exceed any other form described from southeastern Asia and the archipelagoes.

Teeth: maxillary-premaxillary, 31-32; vomeropalatine, 32-33; mandibular, 28-29; splenial, 0-0.

There are two small glands present on each side of the vent in its anterior part; the vent interrupts three folds; the length of the tail in total length, approximately 70 times.

Color in fixative: Dorsum and venter black with a cream lateral stripe, the edges of which are very irregular. Anteriorly it begins under eye, passes back to neck where it widens and continues to level of vent narrowing posteriorly; a small cream spot at vent, at tentacle and nostril; ring about eye gray-white; chin and throat deep black. There are many minute black flecks on the cream stripe.

Measurements in mm.: Total length, 425; tail, 6; width of body, 16; width of head, 10.7; length of head, 14.

Remarks: The specimen has been somewhat dehydrated and in such places the black has become olive, and the ventral black shows a whitish surface.

Another specimen U. S. N. M. No. 129463 bears a similar label but this is unquestionably a different species. It differs among other characters in having approximately 100 less folds and there is a series of splenial teeth present.

The characters of the black color, the large number of vertebrae (123), the large number of folds, and absent splenials set this species apart from other Asiatic forms with a lateral stripe.

Ichthyophis paucisulcus * sp. nov.

Type: U. S. National Museum No. 103565; from Siantar, Sumatra; National Geographical-Smithsonian Institution Expedition, coll.

Diagnosis: A short, broad species the width in length about 17 times; transverse folds on body, 259 dorsal count, 263 lateral count, folds on tail, 5-6; tail length in total length, approximately 54 times;

* pauci (Latin) = few + sulcus (Latin) = groove.

splenial teeth 14-14; choanae oval (not angular); grooves not meeting on venter except in posterior part of body; folds forming a very obtuse angle on median ventral line except posteriorly where the grooves and folds go straight across venter. A narrow cream lateral stripe, not broken on neck.

Description of type: Head nearly as broad (11.2 mm.) as long (12.6 mm.); eye-spot elevated, circular, showing a darker center and a ring of cream; tentacular opening lunate, situated near lip, distinctly closer to eye (1.6 mm.) than to nostril (3.7 mm.); distance between eyes (7.4 mm. measured on curve) much greater

FIG. 34. *Ichthyophis paucisulcus* sp. nov. Type. U. S. N. M. No. 103565, Siantar, Sumatra. Actual length, 256 mm.

than snout length (5.2 mm.); nostril 1.2 mm. distant from lip; eye, 1.8 mm. from same; eye from nostril, 4.7 mm.

Snout to first nuchal groove, 13 mm., to second, 16.8 mm., to third, 20.2 mm. (the measurements made on side of head); first groove distinct, passing entirely around head; second distinct below and on sides to level of mouth; third distinct laterally, absent on throat, dimly indicated above; folds forming an obtuse angle on venter except posteriorly where they are straight; grooves cannot be traced across venter in anterior half of body; folds, dorsal count, 259; lateral count, 266. A few of the folds split on the side; vent longitudinal, interrupting four folds. A pair of slight swellings on each side of vent suggest the presence of special glands; 5 or 6 folds on tail from front of vent; small scales are present on dorsum on anterior part of body but do not pass to ventral side; posteriorly the scales increase in number of rows in each fold and they are continuous around body, as many as four or five rows present posteriorly.

Teeth: maxillary-premaxillary series, 28-28; vomeropalatine, 26-27; mandibular, 28-28 the posterior teeth very small; splenial, 14-14. The tongue (injured) has a triangular thickened anterior part that probably covers the splenial tooth series; the remainder of the tongue is thinner and striated.

Color in preservative: Above lavender-slate; a longitudinal cream stripe beginning as a narrow line below eye, passes back laterally and is interrupted at the third costal groove; the stripe widens and terminates laterally at level of vent, the edges of stripe not discrete; entire venter with rather indistinct very numerous markings of lavender and tan, not strongly contrasting, placed transversely; a well-defined cream spot surrounds vent; a cream spot at tentacle; tip of snout light; the lower lips cream, the jaws grayish below with a grayish spot on chin. The stripe does not bifurcate at angle of the mouth.

Measurements in mm.: Total length, 256; tail, 4.7; body width average about, 15; width in length about 17 times; head width, 11.2; head length, 12.6; tail length in total length approximately 55 times.

Remarks: A specimen obtained by W. L. Abbot on North Pagi Island in the southeastern part of the Mentawai group may belong subspecifically with the preceding species. It differs in having teeth and bones green, a condition most probably caused by some accident of preservation. The characters of this specimen show some significant variation. It is slenderer proportionally, the head longer,

FIG. 35. *Ichthyophis paucisulcus* sp. nov. A specimen U. S. N. M. No. 31701 from Pagi I, Mentawai Group, Sumatra, referred to this species. Actual length, 210 mm.

slightly fewer body folds (9). The vertebrae number 104. The lateral light stripe is narrow and indistinct.

Total length, 201; tail, 4; tail in length, 50 times; body width, average, 10; width in length, 20 times; head width, 9; head length, 12.4; tip of snout to first groove, 9.6; to second groove, 12.6; to third, 15.2; total folds on body, 250; folds on tail, 8. Teeth: Maxillary-premaxillary series, 22-20; vomeropalatine, 22-22; mandibular, 22-23; splenial, 10-10. Tongue somewhat pointed, not covering splenial teeth.

Ichthyophis supachaii sp. nov.

Type: EHT-HMS No. 35498, 10 km. west Nakon Si Thamarrat, Nakon Si Thamarrat province, taken Apr. 30, 1958 by E. H. Taylor.

Paratypes: EHT-HMS Nos. 35497, 35499. Topotypes same date and collector. No. 34677 young, transformed 18 km. N. E. Betong, Yala, Nos. 35781-82 larvae and one transformed young, No. 35780 Kao Chao Forest Station near Trang, Trang Prov., Nos. 35594-96 larvae and No. 35593 young transformed specimen, Rompibong Tin Mine, Nakon Si Thammarat.

Diagnosis: A relatively slender, elongate species, the largest specimen known, 306 mm., with a lateral cream stripe broken on neck; numerous scattered cream spots on dorsum and venter; width in length, 30.6; tail in length 102 times; mandibular teeth reduced in number, the splenials 18-18 becoming more prominent; folds 322; larvae transform at small size (before a length of 125 mm. is reached); tentacle nearer to eye than to nostril.

Description of type: Head rather flattened, its greatest elevation, 3.2 mm.; width of head (9.2 mm.) less than the length (13 mm.); distance between eyes (6.2 mm.) greater than length of snout in front of eyes (5 mm.); tentacle conical, the opening somewhat lunate, closer to eye (1.8 mm.) than to nostril, 3.5 mm.; distance between eye and nostril, 4.8 mm.; tip of snout to first nuchal groove, 12.2 mm.; to second, 16.4 mm.; to third, 20 mm.

Primary and secondary folds, 322, with 4-5 on tail; the grooves failing to meet dorsally or ventrally anteriorly; scales absent in anteriormost folds, appearing first dorsally where they are in a single row in each fold, and about one-half millimeter in diameter; posteriorly they are both dorsal and ventral, surrounding body, in from three to five rows in each fold, overlapping transversely.

Teeth: maxillary-premaxillary, 31-32; vomeropalatine, 27-27; mandibular, 8-6; splenial, 18-18. Tongue oval, rather narrowed anteriorly, not covering, in fact not reaching, the splenial teeth.

FIG. 36. *Ichthyophis supachaii* sp. nov. Type. E. H. T. No. 35498, 10 km. W Nakon Si Thammarat, Thailand. Actual length, 306 mm.

Color in life: Above dark plumbeous lavender; gray slate below; a spot of cream near mouth angle; another spot on side of pharynx; a cream lateral stripe begins at the third nuchal groove and continues to a point somewhat in advance of the vent; numerous flecks and spots of cream on venter, a few present on dorsum. Eye with a pearly lens surrounded by a fine ring of black, and a narrow, incomplete ring of cream about eye, a cream spot about tentacle and one about vent; extreme tip of tail light; a small median cream spot on occiput.

Measurements in mm.: Total length, 306; tail length, 3; width of body, approximately, 10; width in length, 30.6 times; tail in length, 102 times; width of head, 9.2; length of head, 13.

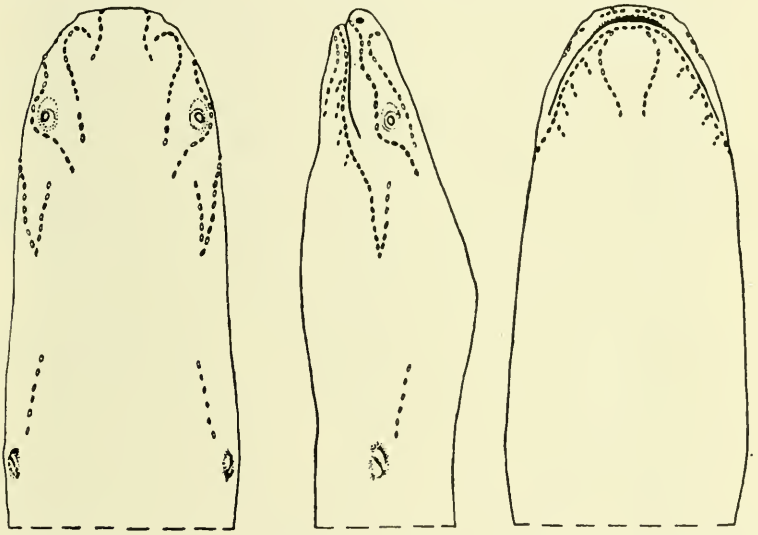

Fig. 37. *Ichthyophis supachaii* sp. nov. Paratype larva, E. H. T. No. 35781, near Trang, Trang Prov., Thailand. Actual length, 97 mm.

Remarks: Two small specimens, one recently transformed, were taken with the type in clay soil on the bank of a small stream. It would appear that the species completes its transformation when it is less than 125 mm. in length.

Measurements of EHT-HMS No. 35499 topotype: This is the smallest of the two topotypes and has the following characters: Total length is 125 mm.; the tail, 2.8 mm. (a portion of the caudal fin is still evident in a compressed ridge that extends along the dorsal surface of the tail reaching the tail tip). The width of the body is about 5 mm., the width of head, 4 mm., the length, 7 mm.

The transverse folds number 313, seven being confined to the tail. The folds meet in an obtuse angle ventrally as they do in the type.

The teeth foreshadow the condition obtaining in the adult but all the series are reduced. I count only five maxillary-premaxillary teeth on each side. In the vomerine series there are seven on each side. In the mandibular series I find a pair of very tiny teeth near the symphysis, then three widely spaced enlarged teeth. In the posterior part of jaw there is a single tooth visible on one side, two on the other. The splenial series has two enlarged anterior teeth (as large as the mandibular), followed by three symmetrically spaced teeth on each side. The tongue lies completely behind the splenial row, and is poorly developed at this stage.

The young larval specimens do not show the white spotting on dorsum or venter. There is a small cream mark running from the eye (which is distinct) to the tentacle. The gill opening is single.

The characteristics of the mandibular teeth distinguishes this species from all others here recognized.

The species is named to honor Prof. Supachai Vanijadhana, Secretary General of Chulalongkorn University, whose interest in the faunas of Thailand made possible my journeys in that country.

Ichthyophis kohtaoensis sp. nov.

Type: U. S. National Museum No. 72293, Koh Tao Island, west side, Gulf of Siam, Malcolm Smith collector, (field number 2932).

Paratype: U. S. National Museum No. 76138, topotype, same collector.

Diagnosis: A form with lateral stripes; a large series of splenial teeth (17-18); number of transverse folds, lateral count, 362-366; tentacle small, opening near lip, closer to eye than to nostril; eye very distinct; light stripe widens on side of head and bifurcates at mouth, terminating anteriorly below eye; posteriorly, somewhat in advance of level of vent; width in length about 24 times; known length, 280 mm.

Description of type: Head rather narrow, the pharyngeal region a little wider than head; width of head at first groove, 8.7 mm.; length of head, 12.1; width between eyes, 5.8 mm.; length of snout, 4.4 mm.; tentacular opening curved, small, near edge of lip, closer to eye (1.7 mm.) than to nostril (3 mm.). Eye distinct, the lens light surrounded by a narrow black rim, the eye itself surrounded by a narrow cream ring. First nuchal groove on neck, distinct on

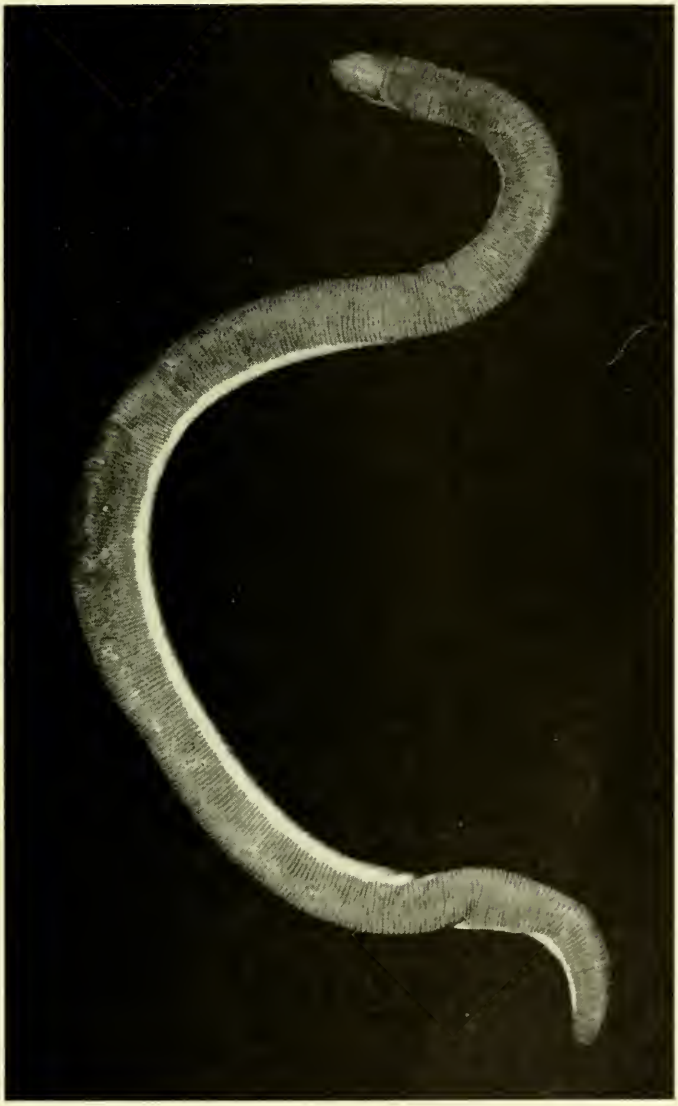

Fig. 38. *Ichthyophis kohtaoensis* sp. nov. Type. U. S. N. M. No. 72293, Koh Tao Island, west side, Gulf of Siam. Actual length, 280 mm.

sides and below; second groove strong below, reaching above the lateral light line; third groove can be traced around neck except on the median ventral point; three dorsal folds lie between the second and third nuchal grooves; the subsequent folds turn back somewhat on venter and meet on midventral line at an angle; the grooves fail

to cross the ventral surface except posteriorly in front of vent where the folds and grooves cross the venter in a straight line; longitudinal vent interrupts about four folds. Total transverse folds (dorsolateral count including the three dorsal) 362 of which six are confined to the tail; tail narrowing suddenly to a point, the subcaudal region flattened.

Scales present anteriorly (seemingly none on the three pharyngeal folds); at first an occasional small scale is present; more posteriorly scales increase in size and in number and two to three (perhaps four) rows of imbricating scales varying in size, are present in each fold the rows overlapping and extending around the body.

Teeth: maxillary-premaxillary, 22-23; vomeropalatine, 22-23; mandibular, 21-20; splenial, 17-18. Vomeropalatine teeth scarcely extending through gums.

Color in preservative: Generally lavender brown, the grooves lighter giving an effect of minute bands of light and dark; a broad lateral stripe of cream from eye to a point a little in advance of level of vent; a cream area about vent; venter same shade as dorsum; the lateral stripe widens behind mouth angle and bifurcates, the lower branch short, quickly becoming brownish; a small cream ring about eye; a cream area around tentacular opening, and one around nostril; lips and tip of snout light brown to brownish cream.

Measurements of type and paratype in mm.: Snout to vent, 280; 192; tail, 4.2; 3.3; width of head, 8.7; 6.9; length of head, 12.1; 9.6; width of body, 12.2; 8.2; width in length (times), 23; 23.4; tail length in total length (times), 66.6; 60.

Remarks: The paratype has a pair of triangular yellow cream spots on each side and slightly behind vent, of a shade lighter than the spot about vent. There are 366 folds (dorsolateral count). The teeth are: maxillary-premaxillary, 21-22; vomeropalatine, 16-17; mandibular, 19-19; splenial, 13-14. These specimens are from Koh Tao, a small island some 70 km. off the eastern shore of peninsular Thailand.

They differ from the mainland form chiefly in having a larger number of transverse folds on the body. The largest count made for specimens from the mainland of Thailand nearest these islands is 323 a difference of about 39 folds. Farther to the northeast in specimens from Viet Nam my highest count was 344.

The island of Koh Tao would appear to have had a somewhat different history from many of the islands in the Gulf of Siam. A number of its forms of reptiles and amphibians differ so much from

the mainland species that they have been recognized by species or subspecies names. As yet the island is little explored. The species is named from the island + ensis (Latin) place, country.

Ichthyophis beddomei Peters

Ichthyophis Beddomii Peters, Monats. K. Akad. Wiss. (Sitz. phys.-math. Classe), Nov. 1879, p. 932, pl. fig. 4 (type locality Nilgherries, India).

Diagnosis: A species having 240 transverse folds; the tentacular opening almost equidistant from eye and nostril; snout more pointed than in *glutinosa;* splenial teeth well developed; length, 225.

Description: "Nur 240 Hautfalten. Die Tentacle-grube kaum weiter von dem Nasloch als von dem Auge entfernt. Schnause spitzer als bie der vorhergehenden Art. Wie bei der vorigen an jeder Seite eine gelbe Längsbinde. Zweite Reihe der Unterkieferzähne wohl entwickelt. Totallänge 0,225; Kopf 0,011; Körperbreite in der Mitte 0,010.

"Von den Nilgherries. Wir verdanken diese Art der Güte des Hrn. Colonel Beddome. (M. B. No. 5545)."

It seems almost certain that this species is one distinct from *glutinosa* differing in having a hundred less transverse folds than the Linnean species.

This species was synonymized by Boulenger but an examination of the material that he studied now remaining in the British Museum shows that he has confused two or more forms.

Ichthyophis tricolor Annandale

Ichthyophis glutinosa tricolor Annandale, Rec. Ind. Mus., vol. 3, 1909, p. 286 (type locality, Maddathorai, India); *idem.*, vol. 9, pt. 4, no. 19, Aug. 1915, pp. 346-347 (Western Ghats, Cochin).

Diagnosis: A species having a white venter.

Description: Annandale describes the form very briefly as follows: "A specimen was taken at Maddathorai in a hollow tree. It had the whole of the ventral surface pure white, and therefore different in appearance from the typical form. A careful comparison, however with normal specimens, including a microscopic examination of the scales, reveals no other difference. I propose to call the form with the white ventral surface,—var *tricolor.*"

Remarks: Annandale in 1915 reported two more specimens as follows: "Two specimens of this variety or local race were found by Mr. F. H. Gravely on the eastern slopes of the Western Ghats in Cochin in September last, the exact locality being Parambikulam (alt. 1700-3200 feet). The specimens are considerably larger than

the type, one of them being 280 mm. long. The yellow lateral band on each side is separated from the white median ventral band by a dark one, which is greyish in spirit. This dark band varies considerably in breadth."

The striking difference in coloration strongly suggests that we are dealing with a distinct species rather than a color variety since there are at least three other species of the genus occurring in the same general locality. The color pattern is normally very constant in caecilians. Since Mr. Annandale did not report on folds, teeth, vertebrae, and other significant characters, complete description must await re-examination of the type. Moreover we do not know what species Annandale used for comparison.

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A Review of the Genus Paroxystoglossa[1] (Hymenoptera: Halictidae)

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Since the genus *Paroxystoglossa* was described (Moure, 1940), several additional species have come to hand. All known species occur in southeastern South America, from Brasil to Argentina. The species are enumerated and described below.

Paroxystoglossa jocasta (Schrottky)

Oxystoglossa jocasta Schrottky, 1910, Rev. Mus. Paulista, vol. 8, p. 74.
Halictus mallotes Vachal, 1911, Misc. Ent. [Narbonne], vol. 19, p. 42, 43, 50.
Paroxystoglossa jocasta jocasta, Moure, 1940, Arq. Zool. [São Paulo], vol. 2, p. 60; Moure, 1943, Rev. Ent. [Rio de Janeiro], vol. 14, p. 477.
Paroxystoglossa jocasta curitybana Moure, 1940, Arq. Zool. [São Paulo], vol. 2, p. 60.
Paroxystoglossa jocasta, Moure, 1950, Dusenia, vol. 1, p. 311.

The type locality of this species is Campos do Jordão, 1600 meters altitude, São Paulo, Brasil. *Halictus mallotes* was described by Vachal from Paraná and from "Bresil (Sello)," the latter specimen being very probably from the state of São Paulo. The color variant that I gave the name *curitybana* is from Curitiba, 900 meters altitude, Paraná, Brasil. The type of *jocasta* is in the Departmento de Zoologia da Secretaria de Agricultura, São Paulo; that of *curitybana* is in my collection in Curitiba.

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The pilosity and punctation are rather constant in this species, in which, however, the metallic coloration varies from blue green to golden green, and in many specimens the abdomen is more or less strongly coppery red.

Distribution: Paraná (Curitiba, Ponta Grossa, Palmeira, Colombo, Campo Largo, Guarapuava, São José dos Pinhais), São Paulo (São Paulo, Guarulhos, Campos do Jordão), and Minas Gerais (Fazenda dos Campos, Passa-Quatro); all these localities in Brasil.

Paroxystoglossa barbata sp. nov

Female: Color entirely metallic green, passing gradually to blue on the marginal depressions of the tergites, their extreme margins bleached; mandibles brown, reddish in the middle, with a green spot basally; apical part of clypeus black with some red reflections; scape brown, nonmetallic, flagellum paler brown; extremities of tibiae and tarsi brown, nonmetallic on the posterior basitarsus, sternites with median bands of greenish. Tegulae brown, the anterior outer third translucent whitish, with small elongate green spot on the anterior inner margin. Pilosity of wing membrane as well as veins and pterostigma honey colored, vein R darker.

Pilosity white, well developed, especially on face, genal areas, episterna, sides of propodeum and sternites; on the tibiae and tarsi, as well as sides of rima of fifth tergite, very pale brown.

Punctation very dense and fine on the front and vertex, passing to a little coarser and sparser on the lower paraocular areas; very fine and dense on upper genal areas and much sparser below; on clypeus and supraclypeal area coarser, although very sparse on disc and finer at sides; on mesonotum a little less dense than on frons or on scutellum, rather uniform, only a little sparser on anterior part; on mesepisterna dense above, considerably sparser below anteriorly, finer and denser near metepisterna; metepisterna roughly punctulate; sides of propodeum rough, postbasal angles and posterior surface shining, microreticulate, piliferous punctures fine. First two tergites with punctation much finer than on mesonotum, rather dense, even on marginal depressions; terga three to five a little more sparsely punctate, especially on discs.

Head distinctly broader than distance from clypeal margin to anterior ocellus (143:105); upper interorbital distance greater than lower, this a little less than eye length (90:82:85); interocellar distance slightly less than ocellocular (24:26); scape longer than half maximum width of face (65:53), surpassing vertex; frontal

carina evident only below; malar area linear. Anterior part of mesonotum with almost semicircular contours, little salient and feebly depressed in middle; corners of pronotum forming very obtuse angles with rounded apices; punctulation of metanotum very evident. Basal area of propodeum shorter than metanotum, with semilunar depression, posterior carina rather evident, forming a broadly open V, surface roughened, with strong central carina and vestigial basal radiating carinae.

Length 9 mm.; wing length including tegula 9.7 mm.; width of head 2.4 mm., of abdomen 3.3 mm.

Male: Color as in female, with green spot on base of mandible, scape metallic green and pedicel with greenish reflections; clypeus wholly green; flagellum darker, especially basally; posterior basitarsus with green reflections on the outer face.

Pilosity white, even more developed than in female, especially on genae and all the venter; on tibiae white, and on apical tergites with some pallid hairs among brown ones.

Punctation as in female, but a little denser on frons; on supraclypeal area and clypeus intervals little broader than punctures, dull reticulate on former; punctation stronger on episterna, well defined and rather strong on sides of propodeum; on tergites a little stronger but much finer than on mesonotum, even on sides of first tergite.

Head distinctly longer than clypeocellar distance (145:105); upper interorbital distance equal to eye length, considerably greater than lower interorbital distance (85:85:70); interocellar distance clearly less than ocellocular distance (23:26); scape less than half as long as facial width but longer than two first flagellar segments together; first flagellar segment a little shorter than second, which is clearly shorter than first and pedicel together; frontal carina almost reduced to an interantennal tubercle; malar area linear; preoccipital carina absent. Anterior part of mesonotum a little produced, forming a semicircular prominence, the anterior median part of which is slightly depressed. Femora and tibiae, especially of posterior legs, a little swollen. Basal area of propodeum still more prominently margined, semilunar, the carinae a little more evident than in female. Metasoma with fourth and fifth sternites more sclerotized medially and depressed forming a canal which narrows toward apical margin of fifth sternite.

Length 9.5 mm.; wing length including tegula 6.7 mm.; head width 2.4 mm.; abdominal width 2.8 mm.

Distribution: Tandil, 250 meters altitude (type locality), November, 1954 (F. H. Walz) and Lavallel, March 20, 1952 (M. Senkute); both localities in the Province of Buenos Aires, Argentina.

Types: Holotype, allotype, and a female paratype in the Snow Entomological Museum, University of Kansas; two paratypes (male and female) in the collection of the author; one female paratype in the Museo Nacional "Bernardino Rivadavia," Buenos Aires.

Paroxystoglossa transversa Moure

Paroxystoglossa transversa Moure, 1943, Rev. Ent. [Rio de Janeiro], vol. 14, p. 477; Moure, 1944, Rev. Ent. [Rio de Janeiro], vol. 15, p. 275.

This species was described from Puerto Bertoni, Paraguay, and all known specimens come from the Paraná basin, several hundred specimens being at hand from Nova Teutonia.

The variation in coloration in the females is extraordinary, as was noted in 1944. Among specimens from Nova Teutonia at the University of Kansas are all color variations previously noted as well as specimens which are entirely dark brown and some approaching blue. Examples with the head and thorax green and abdomen red are also relatively common.

In males the coloration is generally green, passing to gold, and sometimes weakly coppery on the abdomen.

On the contrary the characters noted in the key are very constant, although the size of the females varies considerably. This species would seem to be very interesting for biological study in view of the great size variation among females.

Distribution: Santa Catarina, Brasil (Nova Teutonia); Paraguay (Puerto Bertoni and Hohenau).

Paroxystoglossa brachycera sp. nov.

Female: Color metallic green, sometimes with golden reflections or even passing to blue green, tergal margins a little translucent; mandibles brownish black, without metallic basal spot; anterior third of clypeus dark with some purplish reflections; scape brownish black, nonmetallic, flagellum rather dark; apices of tibiae and tarsi brown, posterior basitarsi nonmetallic; sternites with median band of metallic green, bleached. Tegulae dark brown with a green spot anteromedially, translucent anterolaterally; veins, pterostigma, and pilosity of wing veins pale honey colored, vein R a little darker.

Pilosity white, a little less abundant than in *P. barbata* and *jocasta*, longer on genal areas, sides of thorax, and ventral sides of thorax and abdomen than elsewhere, that of tibiae and tarsi and sides of rima of fifth tergite very pale brown.

Punctation very dense and fine on frons and vertex, passing to sparse on lower paraocular areas, sparser and surface more shining than in *barbata* or *jocasta*, intervals between punctures equal to or greater than puncture widths; clypeus and supraclypeal area a little more shining with fewer punctures laterally; punctures of mesonotum and scutellum almost as dense as on frons, but on anterior median part of former sparse, intervals between punctures dull reticulate, over twice puncture widths; of mesepisternum above a little coarser and slightly sparser than that of mesonotum, passing to very sparse below; of metepisternum finer and shallower; sides of propodeum a little roughly punctate, on postbasal angle and posterior surface much less so; first two tergites entirely much more finely punctate than mesonotum, distinctly sparser on first than on second, third a little denser than second.

Head distinctly broader than clypeocellar distance (136:106); upper interorbital distance longer than lower and equal to eye length (84:78:84); interocellar distance clearly less than ocellocular (20:25). Scape longer than half the maximum width of face (65: 49), surpassing the vertex; frontal carina interantennal, ending at a point about half way from lower end to median ocellus; malar space linear. Mesonotum anteriorly weakly produced medially, pronotal corners forming obtuse angles with rounded apices; metanotum irregularly punctulate. Basal area of propodeum broader than metanotum (26:19), not depressed in semilunar form, but, with very short radiating basal carinae, and with reticulate part forming cusp shaped figure.

Length 9 mm.; wing length including tegula 6.7 mm.; width of head 2.3 mm.; of abdomen 3.1 mm.

Male: Color as in female, but with green spot at base of mandible, clypeus entirely green, scape with metallic reflections, flagellum quite dark, especially first segment; posterior basitarsi dark brown without metallic reflections.

Pilosity white, better developed than in female, but much less than in males of other species.

Punctation as in female but a little denser on frons and mesonotum, a little sparser on scutellum; on clypeus and supraclypeal area sparser than in female and intervals between punctures shining; on episterna a little denser than in female; but punctation little evident on sides of propodeum; on tergites a little stronger than in female, but finer and sparser than on mesonotum, even on sides of first tergite.

Head considerably broader than clypeocellar distance (140:110); eye length greater than upper interorbital distance and this greater than lower (90:85:68); interocellar distance almost equal to ocellocular (23:24). Scape slightly shorter than half of maximum facial width (40:50) but clearly longer than first three flagellar segments together, latter three segments of about same lengths and each about as broad as long; malar area linear; frontal carina vestigially indicated above interantennal tubercle; preoccipital carina absent. Mesonotum with anterior part little produced, as in female; femora and tibiae little swollen, even posterior pair. Basal area of propodeum without semilunar depression, a little longer than metanotum, carinae a little more evident than in female; metasoma with fourth sternite a little emarginate, fifth more sclerotized medially and there depressed to form a canal that narrows toward apical margin.

Length 9.1 mm.; wing length including tegula 7 mm.; width of head 2.3 mm.; of abdomen 2.8 mm.

Distribution: Tandil, 250 meters altitude (type locality), November, 1954 (F. H. Walz); other specimens, same data (Juan Foerster). The locality is in the Province of Buenos Aires, Argentina.

Types: Holotype, allotype, three female, and fourteen male paratypes in the Snow Entomological Museum, University of Kansas; eight paratypes in the collection of the author in Curitiba, Brasil; three paratypes in each of the following collections: United States National Museum, American Museum of Natural History, British Museum (Natural History), Museo Nacional "Bernardino Rivadavia" (Buenos Aires), and that of Dr. Carlos Alberto Campos Seabra (Rio de Janeiro).

Paroxystoglossa crossotos (Vachal)

Halictus crossotos Vachal, 1904, Misc. Ent. [Narbonne], vol. 12, p. 118; Vachal, 1911, Misc. Ent. [Narbonne], vol. 19, p. 14 (partim?).
Halictus (Corynura?) anthidioides Ducke, 1906 Zeitschr. Hymenopterologie Dipterologie, vol. 6, p. 397; Ducke, 1907, Zeitschr. Hymenopterologie Dipterologie, vol. 7, p. 323.
Paroxystoglossa crossotos Moure, 1943, Rev. Ent. [Rio de Janeiro], vol. 14 p. 477 (partim).

This species was described from "ouest de la Capitainerie des Mines, Brèsil" and the type is preserved in the Paris Museum. This locality was presumably in Minas Gerais. Specimens studied by Ducke were from Barbacena, in south central Minas Gerais. Vachal, in 1911, probably included specimens of *P. andromache* under the

name *crossotos,* as he referred to a specimen from Montevideo. I have seen Ducke's type and have before me a specimen compared with it.

Basically the two original diagnoses agree in principal features that distinguish this species from its nearest relatives.

P. andromache is especially close to *crossotos* and was considered a synonym by me in 1934. It now appears that they are different, as indicated by the characters given in the key.

Distribution: Southern and eastern parts of Minas Gerais (Barbacena) and eastern part of São Paulo (Serra de Bocaina) and western part of Rio de Janeiro (Itatiaia).

Paroxystoglossa mimetica Moure

Paroxystoglossa mimetica Moure, 1950, Dusenia, vol. 1, p. 311.

The type locality is Onda Verde, São Paulo, Brasil.

The collection of the University of Kansas contains a specimen from Rio Caraguatá, Mato Grosso, Brasil, March, 1953 (Fritz Plaumann). This was compared with the type. It is slightly larger, the wing (including tegula) measuring 6.2 mm. In this specimen the greenish bronze reflection of the thorax and abdomen are even less noticeable than in the type and the wings are a little more strongly colored. The veins and hairs of the wing membrane along the center of the wing are yellowish but veins C and R, the pterostigma, the marginal cell, and hairs of the membrane near these structures as well as on the wing open beyond the veins and on the posterior border are dusky.

This species is easily separated from others of its group by the lack of punctation on the first tergite, which is quite shining and polished, with piliferous punctures very sparse on the basal third, and with microscopic piliferous punctures on the apical depression and on the lateral elevations.

Geographic distribution: São Paulo (Onda Verde) and Mato Grosso (Rio Caraguatá), Brasil.

Paroxystoglossa andromache (Schrottky)

Oxystoglossa andromache Schrottky, 1909, Rev. Mus. La Plata, vol. 16, p. 141; Schrottky, 1913, An. Soc. Ci. Argentina, vol. 75, p. 241.
Halictus crossotos Vachal, 1911, Misc. Ent. [Narbonne], vol. 19, p. 14 (specimen from Montevideo only).
Paroxystoglossa andromache Moure, 1940, Arg. Zool. [São Paulo], vol. 2, p. 61.
Paroxystoglossa crossotos Moure, 1943, Rev. Ent. [Rio de Janeiro], vol. 14, p. 477 (part); Moure, 1950, Dusenia, vol. 1, p. 313.

The type locality is Puerto Bertoni, Paraguay. The allotype was described from Curitiba and is preserved in my collection.

In the collections of the University of Kansas, Dr. C. A. Campos Seabra (Rio de Janeiro), the Departmento de Zoologia of the Secretaria de Agricultura (São Paulo), and the author are numerous specimens of this species from Curitiba and Nova Teutônia. This last locality is rather close to the type locality.

It seems probable from the locality that Vachal's record of *crossotos* from Montevideo relates to this species.

Some variations can be noted among specimens of this species. The extent of the areas of yellow pilosity on the wing membrane varies even among specimens from Nova Teutonia. In some the yellow only includes the basal thirds of veins M + Cu and A and adjacent wing membrane, while in others it extends to the separation of M + Cu from cu – a. In no specimen was any yellow observed around the third submarginal cell.

Distribution: Paraná (Curitiba, Ponta Grosso, Guarapuava), Santa Catarina (Nova Teutonia) and Rio Grande do Sul (Esteio), Brasil; Paraguay (Puerto Bertoni); and probably Uruguay (Montevideo). It should also occur in Missiones, Argentina.

Paroxystoglossa seabrai sp. nov.

Female: Color black with faint metallic steel bluish reflections on the clypeus, supraclypeal area, propleura, region of scuto-scutellar suture, more greenish on fifth tergum and genal areas; on legs reflections almost imperceptible. Wings fuscous, with vein and hairs of area in middle of wing from base to a little beyond ends of cells and between veins M and A (V) yellow; rest of wing and veins dark, in contrast.

Pilosity largely white but shorter hairs fuscous, that on fore and middle legs and hind basitarsi with fuscous hairs predominating; terga one and two without apical bands, that of third vestigial, fourth a little more evident, these bands and all vestiture of fifth of a slightly fuscous ferruginous; sternal pilosity long, white.

Punctation very dense and fine on frons, sparser and coarser toward lower parocular areas, clypeus rather smooth with few rather coarse punctures on the disc, denser and finer on upper corners; finer and sparser on supraclypeal area, intervals on disc dull, reticulate, three or four times as wide as puncture widths; on mesoscutum very dense and fine, a little less on upper parts of mesepisterna, passing to very sparse beneath, intervals there three to four puncture widths, dull reticulate, but smoother and wider next to coxae; on metepisterna fine and dense; on sides of propo-

deum with some granulate elevated punctures on a finely roughened surface, posterior face of propodeum similar but more shining; on first and second tergites fine and dense, a little finer and sparser than on mesonotum.

Head distinctly broader than distance from clypeal margin to anterior ocellus (125:95), upper interorbital distance slightly longer than inferior interorbital distance but shorter than eye length (74:70:80); interocellar distance less than ocellocular (40: 55, ocellar diameter 25); scape longer than half width of face (60: 46), surpassing vertex; frontal carina clearly evident in lower three fourths; anterior part of mesonotum projecting over pronotum, bilobed, dorsolateral angles of pronotum salient, rounded, margin to lobe gently concave; basal area of propodeum not defined, somewhat shining, reticulate, with short, very vague striae on basal two fifths.

Size: Length 9 mm.; wing (including tegula) 6.7 mm.; head width 2.2 mm.; abdominal width 2.5 mm.

Distribution: Açude Solidão, Floresta da Tijuca, 500 meters, Rio de Janeiro, D. F., Brasil (type locality), January, 1955 and 1956 (C. A. C. Seabra); Vista Chinesa, Floresta da Tijuca, 600 meters, February 23, 1956 (C. A. C. Seabra); Floresta da Tijuca, February 22, 1956 (C. A. C. Seabra).

Types: Holotype in the collection of Dr. Carlos Alberto Campos Seabra, Rio de Janeiro; paratypes in the collections of the author, the University of Kansas, the U. S. National Museum, and Dr. Seabra.

Paroxystoglossa spiloptera sp. nov.

Female: Like *P. seabrai* but with the following differences:

Green reflections more accentuated on sides of face, upper part of supraclypeal area, genal areas, pronotum, metanotum, mesepisterna above; margins of tergites discolored, more broadly so apically, with green reflections on posterior parts of third and fourth terga and on entire fifth. Wings more hyaline than in *seabrai,* veins and hairs fuscous except small area with yellow hairs consisting of posterior internal two thirds of second and third submarginal cells and adjacent region of second medial cell and small area beyond second r - m, these together forming a distinct contrasting spot; small area of yellow hairs at base of wing.

Pilosity denser covering corners and lobes of pronotum and meta-

notum; tergal fasciae fuscoferruginous on terga two or four; pilosity of fifth tergum fuscous.

Punctation as in *seabrai* but on clypeus and supraclypeal area still sparser and their surfaces smooth and shining; mesepisterna with intervals between punctures dull, reticulate; punctures of sides of first tergite very sparse, almost absent, of disc very sparse with intervals several times as great as punctures in contrast to dense punctation of second.

Head distinctly broader than long (132:100); upper interorbital distance slightly greater than lower which is equal to eye length (86:78:78); interocellar distance distinctly less than ocellocular (50:70, ocellar diameter 30); scape longer than half width of face (60:50), surpassing vertex; frontal carina very short, only lower third evident. Thorax as described for *seabrai.*

Length 7.5 mm.; wing (including tegula) 6.2 mm.; width of face 2.3 mm.; width of abdomen 2.5 mm.

Distribution: Guaruva, Santa Catarina, Brasil, 8 meters, October 30, 1955 (J. S. Moure, C. D. Michener).

Types: Holotype in the collection of the author, Curitiba, Brasil. Ten paratypes distributed among the collections of the Snow Entomological Museum, University of Kansas; Carlos Alberto Campos Seabra, Rio de Janeiro; the U. S. National Museum, and the author.

Specimens similar to those from Guaruva and probably belonging to the same species have been collected in the Floresta da Tijuca with specimens of *P. seabrai.*

KEY TO THE SPECIES OF PAROXYSTOGLOSSA

1. Males 2
   Females 10
2. Second flagellar segment but little longer than first, distinctly shorter than first and pedicel together; scape relatively long and slender, almost reaching level of anterior ocellus; preoccipital carina absent . . . 3
   Second flagellar segment distinctly longer than first, equal to or longer than first and pedicel together; scape short and thick, terminating more than its diameter below margin of anterior ocellus; preoccipital carina distinct at least dorsally 4
3. Antennae relatively short, not reaching scuto-scutellar suture, flagellar segments approximately as long as their diameters; horizontal part of propodeum as long as or longer than metanotum with the depressed area cusp shaped and with short basal carinae; punctation of frons coarser than that of mesonotum, dense, but shining; upper interorbital distance less than eye length; clypeus rather salient; head width little

greater than distance from clypeal margin to upper margin of anterior ocellus (135:120) ..... *brachycera*

Antennae longer, surpassing scuto-scutellar suture, flagellar segments longer than their diameters; horizontal part of propodeum very short, depression semilunar, with radiating striae a little weak; punctation of frons dense, dull, as coarse as mesonotum; upper interorbital distance longer than eye length; clypeus not very salient, but well elevated toward apex; head width considerably greater than distance from clypeal margin to upper margin of anterior ocellus (150:120) ..... *barbata*

4. Abdomen elongate elipsoid, wholly metallic, as are most parts of the legs; femora and tibiae relatively swollen, at least posterior pair ... 5

Abdomen decidedly claviform, largely dark, at least on tergal discs; femora and tibiae normal 6

5. Tergites one to three with marginal depressions glabrous and smooth in strong contrast to strong dense punctation of discs; punctation of first tergum coarser than that of mesonotum, on terga four and five considerably finer and very sparse; anterior and middle femora more swollen than posterior; anterior tibiae metallic green, basitarsi dark brown ..... *transversa*

Tergites one to three with piliferous punctures; punctation of first tergite less strong than that of mesonotum, tergites four and five similar to preceding ones; posterior femora more swollen than anterior and median ones; inner faces of anterior tibiae and all basitarsi pale yellow. *jocasta*

6. Head above and entire thorax dark brown, without metallic coloration or sometimes metanotum weekly greenish 7

Head and thorax entirely metallic green, sometimes a little dark on discs of mesonotum and episterna 8

7. Median region of wing entirely covered with yellowish pilosity, veins in this area also yellow; marginal depressions of terga broadly bleached and covered with contrasting yellow hair [hypothetical characters for the male which is unknown to me.] ..... *crossotos*

Yellow portion of wing limited to basal third; abdominal bands, both of bleached integument and of yellow pilosity, relatively narrow and more or less vestigial on first two terga ..... *andromache*

8. First tergite smooth and shining, with punctation very sparse (at the sides punctures separated by over five times their diameters), on other tergites punctation fine but dense; punctation of frons a little sparse, a little coarser than that of mesonotum; episterna and sides of propodeum reticulate but shining; size small, wing length (including tegula) 5.8 mm. ..... *mimetica*

First tergite rather densely punctate, intervals less than twice a puncture width; other terga densely and relatively strongly punctate; episterna and sides of propodeum dull 9

9. Wing length (including tegula) 6 mm.; dorsum and sides of thorax and upper part of head quite dark; anterior discal part of mesonotum densely punctate, on scutellum rather sparsely punctate at sides of median line ..... *spiloptera*[1]

   Wing length (including tegula) 7 mm.; dorsum and sides of thorax and top of head clear green; anterior discal part of mesonotum less punctate near midline; scutellum densely punctate ..... *seabrai*[1]

10. Color predominantly metallic, even on abdomen; abdomen subelipsoid, 11

    Color dark on thorax and abdomen (see also some *transversa*), with yellow pilosity more or less developed on margins of apical tergites; abdomen subpedunculate; angles of pronotum more clearly marked, as is anterior projection of mesonotum 14

11. Marginal depressions of tergites black, broadened to form black bands especially on first two tergites, depressions glabrous, impunctate, in contrast to strong dense punctation of discs of tergites where it resembles that of mesonotum; basal area of propodeum not depressed, and with fine transverse striae in the middle near posterior declivity ..... *transversa*

    Marginal depressions of tergites similar to rest of discs, with sparse piliferous punctures; punctation of discs of first two tergites considerably finer than that of mesonotum 12

12. Vestiture of discs of tergites two to five consisting of pale or brown hairs and short brown pilosity; scape metallic; tibiotarsal scopa with pale or brown hairs ..... *jocasta*

    Vestiture of discs of tergites two to five entirely brown, as are hairs of tibiotarsal scopa; scape nonmetallic 13

13. Mandibular base with metallic green spot; basal area of propodeum shorter than metanotum, its posterior margin medially elevated as a carina having the form of a very wide open V; punctures of first and second terga rather dense, like those of third or denser ..... *barbata*

    Mandibular base without metallic green spot; basal area of propodeum longer than metanotum, grading into posterior surface without marginal carina; punctures of first tergite considerably sparser than those of third ..... *brachycera*

14. First tergite almost entirely smooth, very shining, with only a few fine, sparse, piliferous punctures in basal region and in marginal depression ..... *mimetica*

    First tergite with at least apical third quite densely punctate, although sometimes punctures fine and shallow and intervals between them smooth and shining 15

15. Marginal depressions of tergites two to four broadly bleached and covered with yellow appressed hairs, giving the appearance of bands that occupy about one third of postgradular parts of terga; first tergum generally with hair band narrower, although clearly visible 16

1. Males here characterized were collected with females, but as the two species occur together there is no absolute certainty that they are correctly associated with the females and I have not designated male allotypes.

Marginal depressions of tergites one and two black, and generally with only blackish hairs; third tergum narrowly pale, fourth more broadly so and with yellow hairs forming a band 17

16. Forewings with veins almost entirely yellow and membrane with yellowish hairs; veins C and R and pterostegina and anterior margin of wing fuscous and with fuscous pilosity in marginal cell; apical margins of first four tergites with yellow pilosity well developed, especially on two to four ..... *crossotos*

Forewings generally with veins of apical half more or less dark, as is the pilosity of the membrane in this area (sometimes only basal third of wing, along the middle, with yellow); bands of terga less yellow, that of first generally little noticeable ..... *andromache*

17. Wings with veins and hairs yellow along middle of wing between M-Cu and A and including cells and veins demarking them, three submarginal cells, the medias and cubitals, inner posterior side of 1st R_1 and a little of third submarginal; rest of wing with veins and hairs dark, in contrast ..... *scabrai*

Wings with veins dark and hairs of membrane fuscus, except small area with yellow hairs including inner posterior two thirds of second and third submarginal cells and adjacent parts of second media and a small part of 2nd r-m, forming a distinct spot contrasting with the rest of the wing ..... *spiloptera*

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Comparative External Morphology and Taxonomy of Nymphs of the Trombiculidae (Acarina)[1]

BY

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ABSTRACT: Laboratory reared nymphs of 46 species of trombiculid mites were used as the basis for morphological and taxonomic studies. The nymphs are free-living and are rarely collected. Chigger mites, the larvae of trombiculids, are commonly found as ectoparasites on many species of vertebrates. Until recently the classification of these mites has been based almost entirely on the larval stage.

Only a few of the known species were available as nymphs; these were members of the genera *Acomatacarus* (2 species), *Chatia* (1 species), *Hannemania* (3 species), *Leeuwenhoekia* (1 species), *Whartonia* (1 species), *Blankaartia* (2 species), *Cheladonta* (2 species), *Euschöngastia* (8 species), *Euschöngastoides* (2 species), *Neoschöngastia* (2 species), *Pseudoschöngastia* (2 species), *Speleocola* (1 species), *Trombicula* (18 species), and *Walchia* (1 species). The morphological work was directed towards the discovery of useful taxonomic characters. When discovered these characters were used to provide diagnoses and keys for subfamilies, genera, subgenera, and species, in a system essentially similar to those based on larvae. Few changes in the classification were made; these were the suppression of the subfamily Walchiinae as a synonym of Trombiculinae, the elevation of *Euschöngastoides* to generic rank, and the transfer of *Euschöngastia loomisi* to that genus.

A comparison of the classification based on nymphs with that based on larvae shows that most genera are distinct, *i. e.*, recognizable by a character or group of characters, in both larval and nymphal stages. The degree of distinctiveness often is not the same in the two stages. No characters were found in the nymphal stage which can be used to diagnose the subgenus *Neotrombicula* (genus *Trombicula*); however, relationships do not seem to be contrary to those shown in the larval stage. In such cases the two systems of classification are in basic agreement. A more serious discrepancy concerns the genus *Euschöngastoides*. Larvae of the two included species fall into two different genera but the nymphs are similar to each other and are amply distinct from

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other species. In this instance the difficulty appears to lie in the use of a single key character which separates two otherwise similar larvae into different genera.

It is proposed that characters of postlarval stages should be considered as additional evidence in the taxonomy of these mites, and that neither larval nor postlarval stages should be given undue weight. While larva and postlarva are adapted to different modes of existence there appears to be no base for weighing characters of any particular stage.

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INTRODUCTION

This paper presents the results of a comparative study of the external morphology of the nymphal stage of the available species of trombiculid mites, with the purpose of evaluating morphological features as specific and as group characters, and presenting workable descriptions of the nymphs studied. This work is necessarily of a preliminary nature and more detailed studies of some features will no doubt produce further valuable information. An attempt was made to include as many species as possible, but nymphs of only a small fraction of the described species were available. Moreover, some of the species included are represented by but one or two specimens. It is hoped that this study will provide a basis for other workers in preparing descriptions and in discerning group characters and features distinguishing the higher categories.

This study is restricted almost entirely to American species, for practical reasons. Nymphs from other regions have been and are

being studied by other workers, including Audy in Malaya, Domrow and Womersley in Australia, Lipovsky and others for Korea, Sasa in Japan, and Vercammen-Grandjean in Africa.

The virtual restriction of this paper to one geographic area seems to preclude any extensive revision of the extant classification based on larvae, since the latter is based on the fauna of all regions. The taxonomic effects of postlarval characters on the larval classification is assessed but changes in the formal classification are kept to a minimum.

The nymphal stage rather than the adult stage was selected for study due to several considerations. The nymph differs from the adult in only three major ways: it is of smaller size, has fewer setae, and has incompletely developed genitalia (Wharton and Fuller, 1952:39). The reduced number of setae is actually an advantage since study of variation of their number is greatly simplified. Preliminary studies of adult genitalia failed to reveal characters of value in distinguishing groups, although characters of this type quite possibly are present. Thus little is lost in choosing the nymphal stage rather than the adult. Moreover, nymphs may be obtained from engorged larvae with relative ease, while the rearing of adults requires not only suitable culture conditions but a food material for the nymphs as well. The proper food for postlarval stages is still a major deterrent in rearing trombiculids (Wharton and Fuller, 1952:24) although much progress has been made towards overcoming this difficulty (Lipovsky, 1954:945). By choosing nymphs instead of adults, a greater number of species, represented by more specimens, was available for study.

In contrast to the larval stage, knowledge of the form and habits of the free-living postlarval stages has only recently been acquired. Although trombiculid adults are but rarely collected in nature, in the past ten years rearing techniques have been devised so that nymphs and adults may be reared from engorged larvae taken from hosts. However, taxonomic descriptions of reared adults, properly associated with their larval stage, have been slow to appear in the literature, and most of the published descriptions are somewhat superficial and inadequate for recognition of the species. Accurate and complete accounts of postlarval stages are restricted to a few species, but these have been made the basis of considerable generalization.

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HISTORICAL ACCOUNT

Th history of the development of knowledge of trombiculids has ben reviewed in several recent publications (Wharton and Fuller, 1952; Womersley, 1952, and others); an account of recent developments should suffice for the purposes of this paper.

Three major evaluations of the Trombiculidae have been published recently, all of which consider both larvae and postlarvae. Wharton and Fuller (1952) presented a classification based on larvae; but it utilizes some postlarval features and includes some partial postlarval diagnoses. This effort summarizes our knowledge of trombiculids and includes detailed synonymies for each species. Womersley (1952) revised the Trombiculidae (of Womersley, Trombiculinae of others) by the use of postlarval evidence. Womersley places greater emphasis on postlarval stages than on larvae and deduces from postlarval evidence that some larval characters which were formerly given generic value may be of no more than specific significance. Audy (1954) discusses characters of both larvae and postlarvae, and comments on various genera. These comments are based largely on postlarvae studied by him. Unfortunately the descriptions of the nymphs mentioned have not yet been published. Audy steers a course between the first two authors cited and apparently has adopted the better features of each.

These papers indicate a trend towards a biologically realistic classification of trombiculids, through a consideration of the characters provided by all stages of the life history.

POSITION OF THE NYMPHAL STAGE IN THE LIFE HISTORY

The stages in the life history of trombiculid mites are egg, deutovum, larva, prenymph (nymphochrysalis), nymph, preadult (imagochrysalis), and adult. The larva, nymph, and adult are active stages; the egg, deutovum, prenymph, and preadult are inactive stages in which development occurs. The larvae are parasitic upon terrestrial vertebrates. The nymphs and adults are free-living and predaceous upon small arthropods and their eggs.

The nymph is the first free-living active stage in the life history. If it cannot endure the physical conditions of the habitat in which it finds itself, or cannot find or compete for food materials, it must eventually perish. The adult, also free-living, probably has much the same requirements as the nymph (laboratory cultures so indicate). Characters of the free-living stages may be considered to be tested first by selection in the nymphal stage and those individuals insufficiently adapted to the particular environment never reach the adult stage and hence never reproduce.

It has been shown that trombiculid larvae, while not host-specific, may occur in greater abundance on one or a few particular hosts. For example, Loomis (1955:255) shows that *Trombicula gurneyi* larvae are found on several reptilian and mammalian hosts, but are found with greater frequency and in greater numbers on those closely associated with decaying logs. The adults have been found in decaying logs, and unattached larvae have been taken from this habitat. The skink, *Eumeces fasciatus,* is closely restricted to this habitat, and consequently a greater percentage of larvae, which detach from this host will find a more suitable habitat, than will those which detach from the rattlesnake, *Crotalus horridus,* not so associated with decaying logs. However, the larvae can apparently engorge themselves successfully on either of these two hosts or on others.

Thus the larval stage seems to serve primarily as a means of dispersal. The nymphal and adult stages might be considered as an "anchor" which binds the species to a particular ecological situation and the larva to a particular set of host relationships.

From these considerations it appears that the nymphal stage is at least as critical as the other stages of the life history. Taxonomic characters of this stage should be as valuable and as stable as the characters of the larva and adult. Of course, a sound classification

must admit taxonomic characters of all stages. It is not proposed that nymphal features should be given more weight than those of any other stage.

MATERIALS AND METHODS

The specimens used in this work were mostly reared from engorged larvae taken from vertebrate hosts. A few nymphs were collected from soil, rodent nests, decaying wood, or from beneath rocks. Methods used in the collection of host animals and in removal of chiggers have been described in detail by Loomis (1956:1218).

Living engorged chiggers were placed in culture dishes or tubes lined with a mixture of charcoal and plaster of Paris (Lipovsky, 1953:4). Nymphs were preserved several days after emergence, and were identified from larval specimens associated with them. In later stages of the work, isolation tubes were found to be valuable. These were made from 1-dram vials by addition of a small amount of the charcoal-plaster of Paris mixture. Inactive engorged larvae were transferred singly from larger culture vials into these isolation tubes. After the nymph had emerged, the larval skin could then be mounted for identification of the specimen. The skin was usually found without difficulty.

Specimens were mounted on standard microscope slides for study. Polyvinyl alcohol with lacto-phenol was used as a mounting medium and was found to be satisfactory; however, preliminary clearing of the specimen in hot lacto-phenol produced better slides than did mounting directly from alcohol. Mounts of living material were usually inferior to mounts of material preserved in alcohol for several days.

A phase-contrast microscope was used for detailed study of the specimens. Drawings were made with the aid of a camera lucida. Measurements of structures were made with an ocular micrometer of the fixed type.

In the preparation of mites for taxonomic study customary procedure includes clearing of the soft internal parts so that only skeletal structures remain. This procedure was followed in this study so no description of the soft anatomy can be given. The account is not entirely restricted to external anatomy, however, since the few sclerotized internal structures remain after clearing. Such internal structures, associated with the gnathosoma and genitalia, are included in the following discussions.

Nymphs of forty-six species of trombiculids are included in this paper. A list of these species is presented below, modified by some changes in classification. In the ensuing discussions the evidence for these changes will be presented. It is somewhat less than logical to present the classification and the changes before presenting the evidence for them, but this course may be justified by the saving of space and by the continuity obtained.

Unfortunately some species are represented by only one or a few specimens. It is hoped that the knowledge of variability gained from longer series of other species has enabled the author to avoid gross errors in characterizing these forms.

No specimens of members of the subfamily Apoloniinae were available for study, so that this group is necessarily excluded from the discussions.

Family Trombiculidae Ewing

Subfamily Leeuwenhoekiinae Womersley

Acomatacarus (Acomatacarus) arizonensis Ewing
Acomatacarus (Xenacarus) plumosus Greenberg
Chatia setosa Brennan
Hannemania dunni Sambon
Hannemania eltoni Sambon
Hannemania multifemorala Loomis
Leeuwenhoekia (Comatacarus) americana (Ewing)
Whartonia senase (Greenberg)

Subfamily Trombiculinae Ewing

Blankaartia alleei (Ewing)
Blankaartia velascoi (Boshell and Kerr)
Cheladonta micheneri Lipovsky, Crossley, and Loomis
Cheladonta ouachitensis Lipovsky, Crossley, and Loomis
Euschöngastia criceticola Brennan
Euschöngastia cynomyicola Crossley and Lipovsky
Euschöngastia diversa Loomis
Euschöngastia jonesi Loomis
Euschöngastia peromysci (Ewing)
Euschöngastia pipistrelli Brennan
Euschöngastia setosa (Ewing)
Euschöngastia trigenuala Loomis
Euschöngastoides hoplai (Loomis)
Euschöngastoides loomisi (Crossley and Lipovsky)
Neoschöngastia americana (Hirst)

Neoschöngastia brennani Crossley and Loomis
Pseudoschöngastia farneri Lipovsky
Pseudoschöngastia hungerfordi Lipovsky
Speleocola tadaridae Lipovsky
Trombicula (Eutrombicula) alfreddugèsi (Oudemans)
Trombicula (Eutrombicula) belkini Gould
Trombicula (Eutrombicula) lipovskyana Wolfenbarger
Trombicula (Eutrombicula) splendens Ewing
Trombicula (Leptotrombidium) myotis Ewing
Trombicula (Neotrombicula) autumnalis (Shaw)
Trombicula (Neotrombicula) lipovskyi Brennan and Wharton
Trombicula (Neotrombicula) sylvilagi Brennan and Wharton
Trombicula (Neotrombicula) whartoni Ewing
Trombicula (Trombicula) crossleyi Loomis
Trombicula (Trombicula) fitchi Loomis
Trombicula (Trombicula) gurneyi Ewing
Trombicula (Trombicula) kansasensis Loomis
Trombicula (Trombicula) kardosi Loomis
Trombicula (Trombicula) merrihewi Loomis and Lipovsky
Trombicula (Trombicula) montanensis Brennan
Trombicula (Trombicula) ornata Loomis and Lipovsky
Trombicula (Trombicula) trisetica Loomis and Crossley
Walchia americana Ewing

EXTERNAL MORPHOLOGY OF THE TROMBICULID NYMPH

Gross Morphology

The generalized form and structure of trombiculid nymphs have been known since the pioneer work of the Japanese investigators. Hirst (1925:609) gives an excellent figure of the audit of *Trombicula autumnalis* and André (1930) gives a clear account of the morphology of that species. Other illustrations and descriptions of some postlarvae were published by various workers prior to and during World War II. Some of these contain inaccuracies since the figures were intended to present the generalized form of the animal rather than exact detail. In 1946 Wharton described the sclerotized anatomy of all stages of *Euschöngastia indica,* with attention to detail. Michener (1946a), Jenkins (1949a), Richards (1950), Wharton *et al.* (1951), Wolfenbarger (1952), Wharton and Fuller (1952), Womersley (1952), Brown (1952), Sasa (1953) and others have described morphological features of postlarvae.

The trombiculid nymph is an eight-legged form with a pair of chelicerae and a pair of palpi. Primary segmentation is obscured. The body may be divided into four general regions, the gnathosoma, the propodosoma, the metapodosoma, and the opisthosoma. The gnathosoma is the region bearing the mouth and mouth parts while the propodosoma bears the first two pairs of legs, the metapodosoma bears the second two pairs of legs, and the opisthosoma is the remaining posterior portion of the abdomen. In most trombiculids the propodosoma and metapodosoma are separated dorsally by a strong constriction, the body anterior to the constriction being called the proterosoma and that posterior to the constriction the hysterosoma. The gnathosoma is the most distinct region, and sometimes the entire body posterior to the gnathosoma is called the idiosoma.

The idiosoma has a single dorsal plate, the scutum or crista metopica, on its anterior dorsal portion. Ventrally, the area between the coxae of the first two pairs of legs is called the sternum. The genital opening and the anus are found on the venter between or behind the coxae of the last pair of legs. One or two pairs of eyes, when present, may be found on the anterior dorsal aspect of the idiosoma.

The four pairs of legs are borne in two groups, two pairs anteriorly and two posteriorly. The tarsi of all legs are provided with claws. All of the legs are used in walking, although the first pair of legs evidently functions as a sensory organ as well.

SETAE

Numerous and highly modified body setae characterize the group of prostigmatic mites to which trombiculids belong. Setae are also numerous and somewhat modified on the appendages. In the family Trombidiidae the forms of the body setae have been much used as generic and specific characters; but in the Trombiculidae, while these setae are not so strongly modified they are still useful as taxonomic characters. The specialized setae of the body and the scutum will be discussed in detail in other sections of this paper but the appendicular setae merit some special consideration.

In the classification of trombiculids based on larvae, the form and position of setae have been used as specific and as group characters. Wharton *et al.* (1951:13) standardized a system of terminology for the appendicular setae which has been widely accepted. The appendicular setae of larvae and postlarvae are essentially similar, so that some features of the terminology for larval setae

may be adapted for postlarvae. This scheme has not been followed invariably, since it seems preferable to propose a new term rather than to misapply the larval terminology.

The setae found on trombiculids fall readily into two classes: thick-walled branched and unbranched (nude) setae, and thin-walled nude setae. Thick-walled setae usually consist of a long stem with an attenuated tip and have few to many shorter branches which arise at more or less regular intervals, and often from several planes. Thin-walled setae are typically shorter, rather thickened, pointed or blunt at the tip, and are often transversely striated. Specializations of both types occur but the only point of confusion concerns thick-walled or "branched" setae which have no branches. Jones (1950:486) described in detail sectioned setae of the larva of *Trombicula autumnalis* and demonstrated that branched setae (both with and without branches) have thick walls while nude setae ("peg organs") have thin walls. Grandjean has called the thin-walled setae "solenidions." The thin-walled condition is evident under the phase-contrast microscope without special preparation, since an internal cavity can be seen in the basal portion of these setae; such a cavity is visible only in some of the larger branched setae and here the thick-walled condition is obvious. Thus in practice the separation of the two types usually presents no difficulties.

In postlarvae, thin-walled nude setae occur only on the appendages, these setae being increasingly numerous on the leg segments distal to the trochanter, and one such seta occurs on the palpal tarsus. All of the setae found on the body, including the nude setae on the hypostome, those on the genitalia, and the sensilla of the scutum, appear to be thick-walled setae derived from the branched type. The larval system for naming the thin-walled setae involves combining the name of the segment on which the seta occurs with the suffix "-ala." Thus, a thin-walled nude seta found on the tibia is called a "tibiala." For postlarvae, the terms basifemorala, telofemorala, genuala, tibiala, and tarsala may be used for these setae. Such terminology is used throughout this paper, the term "nude seta" referring only to thick-walled, unstriated setae that lack branches.

Many of the appendicular setae are set in pits, so that it is usually difficult to decide whether a circular structure surrounding the base of a seta is a pit or an alveolus. In the illustrations an alveolus is shown for each branched seta but is omitted from the thin-walled nude setae. This is probably the condition which obtains.

THE GNATHOSOMA

The gnathosoma is the most anterior and the smallest division of the body. It is completely fused to the propodosoma, with little trace of division ventrally and none dorsally. The gnathosoma consists of a somewhat conical basal portion (basis capituli) bearing the palpi dorsolaterally and the chelicerae dorsally, and a projecting distal portion (hypostome). These parts are discussed separately below.

The morphology of the gnathosoma of the adult of *Trombicula alfreddugèsi* has been well described by Brown (1952), and his descriptions appear to be generally applicable to both nymphs and adults of most species. Brown's work is a morphologic and not a taxonomic effort. His descriptions are difficult to apply in some instances to specimens mounted on slides in the usual manner. Thus discrepancies between Brown's presentation and that of the writer are partly due to differences in purpose and method of study.

Basis capituli. The exact extent of the basis capituli and its connection to the propodosoma are obscured by the process of clearing and mounting. The sclerotized structures mentioned by Brown (1952) may usually be located although no longer in normal position. Most of these sclerotized structures form a capsule (essentially the basis capituli) which is but rarely broken in mounting and is occasionally separated completely from the body. Apparently this capsule consists of the structures which Brown has termed epistome (E), epistomal apodemes (EAs), and apodeme at the junction of the basis capituli with the propodosoma (BCA). The hypostome is found at the distal end of this capsule, and occasionally the palpi remain completely articulated after mounting. The chelicerae are almost invariably displaced and the integumentary connections of the capsule with the body are either destroyed or obscured in mounting. The capsule (fig. 198) is roughly conical in shape, open at both ends and open dorsally, the two sides being connected dorsally by a single sclerotized crosspiece near the anterior end. The posterior margin, the dorsal margins, and the dorsal portions of the anterior margin are sclerotized. Apparently the dorsal portion behind the crosspiece is internal. The depressed space anterior to the crosspiece contains the chelicerae and the palpi are articulated dorsolaterally on the anterior margin. The hypostome projects from the anterior ventral portion.

The shape of the capsule in the species studied is approximately the same as that of *Trombicula trisetica* (fig. 198). The capsule is

somewhat broader and appears shortened in *Acomatacarus plumosus, Euschöngastia jonesi, E. pipistrelli,* species of *Euschöngastoides, Hannemania eltoni,* and species of *Pseudoschöngastia;* it is narrowed and somewhat elongated in *Speleocola tadaridae.*

The cheliceral apodemes (CA) and the skeletal structure forming lateral articulations for the chelicerae (ChA) appear to be firmly connected and usually remain so after mounting although no longer in position.

The pharynx is a broad, flattened tube which can be seen occasionally in the gnathosoma of mounted specimens. However it was not seen in all of the species examined. In certain species (*Euschöngastoides, Pseudoschöngastia,* and *Walchia americana*) the pharynx is quite distinct and is marked with a reticulate pattern (fig. 8). The significance of this marking is not known. In *Pseudoschöngastia hungerfordi* the pattern is restricted to the midline of the pharynx; in the other species the reticulations cover about half the width of the pharynx.

Hypostome. In mounted material the hypostome appears as a lobe projecting from the ventral part of the basis capituli; in unmounted specimens it appears coneshaped with the dorsum open. Mounting distorts the shape of the hypostome but it usually appears triangular and continuous with the venter of the basis capituli. The ventral portion bears setae; the dorsal portion bears a sclerotized hypostomal trough (Brown, 1952).

In most species the hypostome appears triangular and bears about eight nude setae, usually four on each side at the apex (fig. 9). Posterior to the nude setae are about ten to twenty branched setae, similar to those on the venter of the basis capituli. Usually it is impossible to delineate clearly the venter of the hypostome from that of the basis capituli, so that some setae cannot be assigned accurately to either. There is some intraspecific variation in the number of nude setae, occasional specimens having as many as ten or as few as six. These setae occasionally bear one or two fine branches. There are some marked and consistent variations from this typical condition; these merit further characterization.

In *Euschöngastoides, Pseudoschöngastia,* and *Walchia americana* the hypostome is blunt, and occasionally the margin is slightly concave (fig. 8). Along the margin are about twenty short setae which are nude or have one or two branches. Behind these, some twelve longer branched setae are distributed over the venter of the hypostome. In *Walchia americana* the edge of the hypostome is

not as straight as in the other species; usually it is slightly convex.

Species of *Cheladonta* have the hypostome more elongated than do the typical species of the family and the apex bears eight to ten rather short nude setae (fig. 10). About ten nude setae are distributed over the remainder of the hypostome; occasional setae have one or two branches but there are no heavily branched setae on the hypostome.

Species of *Neoschöngastia* have a rather blunt hypostome which bears eight short nude setae on its apex (fig. 11); some ten branched setae are scattered over the more posterior portion. The apical nude setae are very short in *N. brennani* and somewhat longer in *N. americana.*

Acomatacarus plumosus and *Whartonia senase* have a blunt hypostome which bears six to eight apical setae, all of which have several branches. About twenty slightly expanded, branched setae are found on the remainder of the hypostome.

In *Chatia setosa* and species of *Hannemania* the branched setae covering most of the hypostome are quite numerous. Some of the specimens of *Hannemania eltoni* have as many as fifty such setae.

Chelicerae. The chelicerae are composed of two segments; a proximal elongated base and a distal blade. The base is articulated to the basis capituli and has a slight amount of forward-backward movement. The blade is articulated with the base at the sides to allow for dorsal-ventral movement. The chelicerae have no setae.

In mounting, chelicerae usually become partially detached and are seen in side view. This position seems to be favorable for characterizing the base and it is certainly the best position for observation of the blade. All of the drawings of the chelicerae are made from the medial (inner) surface, and all measurements are made in side view.

The base is typically elongated, roughly oval in cross section, pointed posteriorly, blunt anteriorly, with a straight ventral margin and an arched dorsal margin. The area of articulation with the gnathosoma is on the posterior ventral portion and occupies about one half of the length of the ventral portion, extending from the posterior tip forward (see figures). In mounted material the area of articulation is seen to be more on the medial surface than directly ventral (see also Brown, 1952, p. 47, fig. 4; p. 49, fig. 8). The base is unusually elongated in *Blankaartia, Cheladonta, Speleocola tadaridae, Trombicula ornata,* and *T. kansasensis;* the area of

articulation is also elongated in *S. tadaridae, T. kansasensis,* and *T. ornata.* The articulating area appears to extend across the posterior part of the base instead of the ventral surface in *Euschöngastoides, Pseudoschöngastia,* and *Walchia americana* (figs. 30-33, 35). The area of articulation appears shortened in *Neoschöngastia* and *Whartonia senase.* Otherwise, characterization of the shape of the base is difficult, since individual variation, although slight, is noticeable. In some species the base appears to have a more robust shape, *i. e.,* shorter and broader, than in others. However, different specimens of the same species present slightly different aspects and intermediate conditions defy grouping. Aside from the obvious deviations given above, the shapes of the cheliceral bases are more or less similar.

Punctation is generally present on the cheliceral base, and appears to be more dense on the dorsal and perhaps the ventral portions than on the lateral portions. Puncta are difficult to see in poorly mounted specimens and even under good conditions estimates of size and number of the puncta are difficult. Occasional specimens and some species of specimens appear to lack puncta altogether, and specimens preserved soon after they enter the nymphal stage may lack them. Species which have punctation of the cheliceral bases sparse or absent include *Cheladonta ouachitensis, Euschöngastia cricetícola, E. cynomyicola, E. pipistrelli, Euschöngastoides loomisi, Pseudoschöngastia farneri, P. hungerfordi, Trombicula crossleyi, T. gurneyi,* and *T. ornata.* Puncta are particularly numerous on the cheliceral bases of *Euschöngastia diversa, E. jonesi, E. peromysci, E. trigenuala,* and *Hannemania dunni.* Conspicuously coarse punctation is present on the bases of *Hannemania dunni, Leeuwenhoekia americana, Trombicula sylvilagi,* and *T. whartoni.*

The cheliceral blade usually bears a resemblance to a single blade of a pair of shears, so the term "shearlike" has been used in the section on taxonomy to designate this usual condition. The blade is flattened laterally, with an attenuate tip ending in a sharp point and a row of teeth on the dorsal edge. The blade appears to be adapted for piercing rather than for cutting. The proximal portion of the blade is an upright structure, the apodeme of the blade, lying partly within the cheliceral base. The blade articulates with the base at two points, one on each side of the apodeme of the blade. Apparently muscles attach here also. This apodeme is slightly constricted in most species. The constriction is particu-

larly noticeable in species of *Cheladonta, Euschöngastia trigenuala, Trombicula kansasensis,* and *T. ornata.* No constriction was seen in *Acomatacarus, Chatia setosa, Euschöngastoides, Hannemania, Trombicula myotis,* and *Whartonia senase.*

The distal portion of the blade in most species curves upward to an acuminate apex. The blades of some species appear to be broader than others; but as with the shape of the cheliceral base, this character proved very difficult to use. Particularly broad, *i. e.,* deeper and coming to a more abrupt point, are the blades of *Euschöngastia criceticola, E. diversa, E. Peromysci, E. trigenuala, Trombicula lipovskyi,* and *T. sylvilagi.* Related species approach this condition to such an extent that the characterization is somewhat arbitrary (see illustrations). The few following types are sufficiently distinct from the usual blade type to merit description: *Whartonia senase* and *Neoschöngastia* spp. have a considerably narrowed blade which curves up at the tip; the blade of *Acomatacarus arizonensis* is also narrowed but is straight at the tip, being dagger-like; in species of *Cheladonta,* the blade is broad but also strongly curved. Elongations of the usual shape also occur; but these are difficult to single out. However, species of *Blankaartia* seem to show the greatest elongation.

A dorsal row of teeth on the cheliceral blade was found in all species except *Neoschöngastia brennani,* which lacks teeth altogether. It is possible that the two specimens of *N. brennani* are anomalous in this respect. Occasional specimens of other species were found to lack teeth on one of the blades or to have the number greatly reduced. Often, but not always, it appeared that these specimens had been preserved soon after emergence.

Cheliceral teeth vary in size and number among species, within the species, and on the individual specimen. Customarily the largest teeth are found near the base of the blade and become progressively smaller towards the tip, where they are tiny. This is not a regular gradation, however; very tiny teeth frequently occur at the base of the blade, and the row of teeth is usually uneven, with teeth of various sizes occurring together. Some of the configurations suggest that a large tooth may break off, leaving several small points. The irregularity, together with the small size, makes cheliceral teeth difficult to count and somewhat difficult to characterize for a given species. In most instances there is a relationship between the size and the number of teeth, species with larger teeth having the smaller number, if such factors as the size of the mite

or peculiar modifications do not disturb the comparison. This relationship is less noticeable in variation within the species; individuals with different numbers usually have teeth of similar size. Counts of teeth were attempted for all species and these figures are given in the descriptions as approximations. The character of many small versus few large teeth has some value in separating some of the species, but cannot be rigidly applied due to the inaccuracies resulting from difficulty in counting. As noted above, occasional specimens have a blade with the teeth greatly reduced or absent.

Teeth are particularly numerous on the chelicerae of *Chatia setosa, Euschöngastia pipistrelli,* and *E. setosa.* Large teeth, reduced in number, are found in *Cheladonta micheneri, Pseudoschöngastia farneri,* and *Trombicula sylvilagi.* These two groupings include extreme cases; other species show tendencies toward these extremes. Species of *Cheladonta, Euschöngastoides loomisi, Whartonia senase,* and to some extent *E. hoplai,* show a restriction of the teeth to the distal portion of the blade. The row of teeth (the dorsal margin of the blade) is straight rather than curved upwards in *Acomatacarus plumosus, Euschöngastoides, Hannemania multifemorala,* and *Whartonia senase;* however, other species approach this condition.

A membranous structure, the pseudochela, is usually visible as a projection from the dorsal margin of the end of the cheliceral base. This structure has been omitted from some of the illustrations but it is believed to be present in all species although sometimes difficult to see. Possibly it is a remnant of the fixed chela, or simply an extension of the articulating membrane of the base-blade union. The shape is variable, probably being influenced by mounting techniques.

The cheliceral apodemes are visible in most specimens and are generally similar in shape. Specific differences may exist in the shape of the structure but if so they are masked by individual variation. These structures are also frequently distorted during the mounting process. They have not been figured for most species.

Measurements of chelicerae. Since the chelicerae usually fall into side view during the mounting process, and are rarely distorted by mounting, they were considered to be suitable subjects for measurement. It was hoped that a measurement could be found which would serve as an index of total body size, since this is not suitable for accurate measurement due to distortion of the body in

mounting. Three measurements were made on the chelicerae, as follows: BL: Length of the cheliceral base, measured from the posterior extremity to the point of articulation of the blade on the medial surface. BH: Height of the cheliceral base, measured at the widest point. CL: Length of the cheliceral blade, measured from the tip to the back of the apodeme of the blade.

Most of the samples of nymphs are small. Large samples (more than thirty individuals) with identical data were available for *Trombicula lipovskyi* and *T. montanensis*. Graphic checks for normality showed that the three measurements were skewed to the right in *T. lipovskyi* (an abundance of larger values and a shortage of smaller ones); in *T. montanensis* they were normally distributed or nearly so. Two ratios were made from the values, these being BL/BH and BL/CL; these ratios were checked by graphic methods and found to be normally distributed in both species.

It should be emphasized that these measurements were taken in an endeavor to discover taxonomic characters. It is to be expected that two species could differ in a measurement but it is not particularly surprising when they do not; also, the figures given are based on individuals which in some cases are probably members of different populations of the species. This work is intended to show that measurements of the chelicerae are practical for taxonomic purposes, including investigations of variation within a species; that these measurements in some cases may serve as characters for the identification of species; and that the ratios used have a value similar to that of the measurements on which they are based. The measurements are used, however, only to separate species or groups of species from one another where such separation is clear. The ratios serve particularly to quantify relationships which are already obvious.

Means of the three measurements and their ratios, with their standard errors, are given in the species descriptions in the taxonomic portion of this paper. Examination of these will show that some of the species may be separated by cheliceral measurements even though some accuracy is lost because of skewness. Also, the measurements seem to give an indication of the general size of the mite. Within a species group where cheliceral shapes are similar, these measurements more accurately indicate relative size.

The ratios based on these measurements are not valuable in separating closely related species from one another. However, several interesting groupings of species appear, as shown in Tables 1 and 2. These ratios give a quantitative expression to some pe-

culiarities evident in the illustrations, as far as the extreme forms are concerned. That related species have similar ratios may be seen in the Tables.

The ratio BL/BH ranges from about 1.8 to about 4.0. Most of the species have a mean ratio between 2.3 and 3.0; the larger mean ratios of *Speleocola tadaridae* (3.5), *Trombicula ornata* (3.6), and species of *Cheladonta* (4.0) are distinctive. There is also a group of species with mean ratios between 1.8 and 2.1; this group is not so distinctly separated from the majority but is worthy of mention. The group includes *Acomatacarus arizonensis, A. plumosus,* and *Whartonia senase* (1.8); *Leeuwenhoekia americana* and *Pseudoschöngastia farneri* (1.9); *P. hungerfordi, Euschöngastoides hoplai,* and *Walchia americana* (2.0); and *E. loomisi* and *Hannemania multifemorala* (2.1).

The ratio BL/CL ranges from about 1.6 to about 3.7. The only species clearly separated from the rest are members of the genus *Cheladonta* (3.6 and 3.7).

Palpi. The palpi are the second pair of appendages of the gnathosoma; they are attached anteriorly at the sides of the basis capituli and project forward in front of the hypostome. The palpi are arched dorsally, so that the anterior ends point downwards. The segments are hinged on their dorsal margins. Brown (1952: 43) states that none of the muscles of the palpi are extensors. Five free segments are recognizable in the palpus, these being trochanter, femur, genu, tibia, and tarsus. The coxae are incorporated into the basis capituli and are not apparent as segments. The palpus has a chelate apex ("thumb-claw process" of authors); this consists of a "thumb," the palpal tarsus, which articulates near the base of the tibia instead of at the apex, and a claw arising from the apex of the tibia. The chelate apex of the palpus is characteristic of several families of prostigmatic mites.

The most favorable position for observation of the palpi is a side view, so that the medial (inner) and lateral (outer) surfaces are prominently displayed, and the dorsal and ventral surfaces form the margins. The palpi usually fall into this position in mounting.

In general, palpi of the different species have relatively similar aspects. Some appear more elongated than others but a gradation occurs. The short, broadened palpi of *Neoschöngastia* appear to be distinctive in shape but others *(Pseudoschöngastia)* approach this condition. General palpal shape within a species is sufficiently

TABLE 1. The Ratio BL/BH (Cheliceral measurements): Distribution of Species among Taxonomic Categories.

MEAN RATIO	Leeuwenhoekiinae	*Eutrombicula*	*Neotrombicula*	other *Trombicula*	*Euschöngastia*	remaining Trombiculinae
1.8	3					
1.9	1					1
2.0						3
2.1	1					1
2.2						
2.3	2	2	1			
2.4	1		1		4	
2.5		2	1		1	2
2.6			1	1	2	
2.7				1	1	
2.8				1		2
2.9				4		
3.0				1		1
3.5						1 (*Speleocola*)
3.6				1 (*T. ornata*)		
4.0						2 (*Cheladonta* spp.)

TABLE 2.—The Ratio BL/CL (Cheliceral measurements): Distribution of Species among Taxonomic Categories.

MEAN RATIO	Leeuwenhoekiinae	*Eutrombicula*	*Neotrombicula*	other *Trombicula*	*Euschöngastia*	remaining Trombiculinae
1.6	4		1			1
1.7	1	2	1			
1.8	2	1	2		1	1
1.9	1	1		2	4	1
2.0				3	1	3
2.1					2	2
2.2				1		
2.3				2		
2.4						1
2.5						1
2.6						1
2.7						
2.8				1 (*T. ornata*)		
3.0						
3.6						1 (*Cheladonta micheneri*)
3.7						1 (*C. ouachitensis*)

constant, however, that some species may be classified as having palpi "elongated" or "shortened." These terms are subjective and a more valuable characterization of the palpus requires a more detailed discussion.

Certain features of the palpal setae require special consideration. Except for specialized setae on the tarsus, palpal setae may be of two types: unipectinate and bi- or multipectinate. Unipectinate setae are straight setae with branches arising from one side only. The branches are thick basally, taper abruptly, and run parallel to the body of the seta. Other setae are flexible; the branches taper gradually, run in different directions, and arise from more than one side of the seta. These flexible setae appear to be primarily bipectinate with occasional branches slightly out of line. Often in mounting, however, flow of the medium causes all of the branches to point in the same direction; also, the setae may become twisted, so that the exact nature of the branching may be obscured.

On the genu, unipectinate setae are found on the dorsal margin and bipectinate setae on the ventral margin, with intermediate conditions on the lateral portions. The intermediates are more stiff than the ventral setae and are occasionally unipectinate.

Setae on the femur are similar to those of the genu, except that the dorsal setae are usually bipectinate and differ from the ventral setae only in being more stiff, although not as straight as the dorsal genual setae.

The trochanter is a small, somewhat triangular segment. This shape is fairly constant within species, and most of the species have similar trochanters. Species of *Cheladonta* are characterized by a noticeable elongation of the trochanter (fig. 85). *Whartonia senase* (fig. 60) and *Acomatacarus plumosus* (fig. 88) have short broad trochanters, otherwise no distinction among species was noted. There are no setae on the trochanter. The articulation between trochanter and femur does not appear to be flexible.

The femur is the longest palpal segment. The shape of the femur is similar in all species. It is narrowed at the proximal end and broadened at the distal end. In *Neoschöngastia* (figs. 71-72) the femur is extremely broadened. It is slightly arched and the apparent shape varies somewhat with the position of the palpus on the slide. A number of setae are borne on the femur and taxonomic characters were found in the number and nature of these setae. In general, the dorsal setae are thicker and stiffer than the ventral ones. Elongated setae are often found on the

lateral and medial portions of the femur. Setae with reduced branching and occasional nude setae were noted in *Blankaartia* and in *Speleocola tadaridae* (fig. 86). *Leeuwenhoekia americana* has distinctive dorsal femoral setae. In *Acomatacarus arizonensis, A. plumosus,* and *Whartonia senase* some of the femoral setae are expanded (fig. 88). The dorsal femoral setae of *Trombicula (Eutrombicula) belkini* (fig. 79) have many more branches than do those of other members of that subgenus.

The mean number of femoral setae for each species is given in the descriptions of species. To obtain this figure the setae were counted on both femora and an average number obtained for each specimen. The means given are based on these average values. Occasionally one femur is obscured to the extent that the setae cannot be counted but usually, at least one femur is clearly visible on each specimen. The number of setae on the femur is a characteristic which may be used in separation of species. Usually, related species have about the same number of femoral setae but the exceptional cases provide taxonomic characters. Also, members of the subfamily Leeuwenhoekiinae have a greater mean number of femoral setae than do the species in Trombiculinae (see Table 3). No other categories are clearly separated.

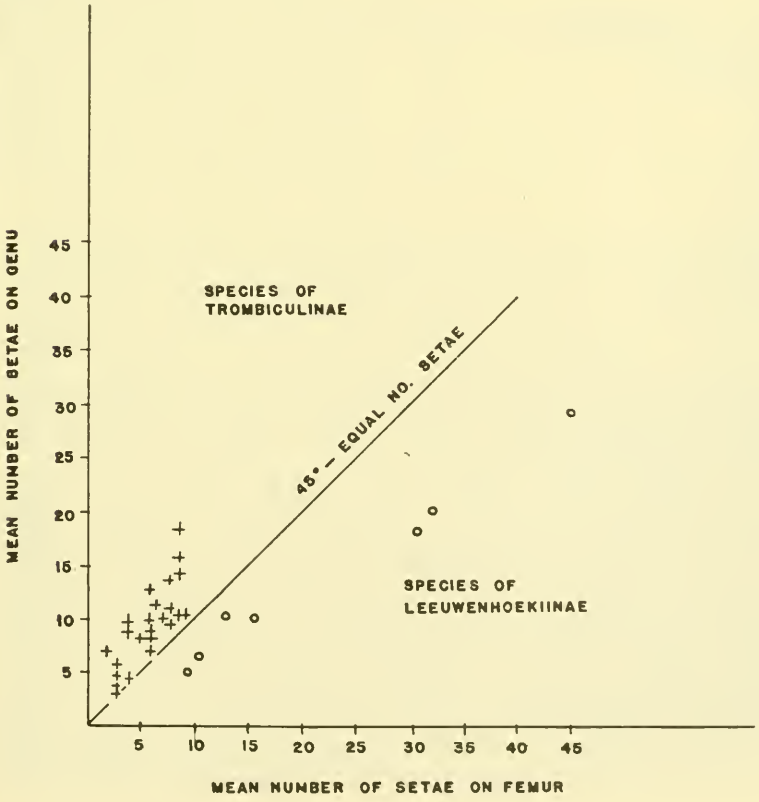
It seems reasonable that the number of setae on a segment could be correlated with size. Unfortunately measurements of palpal segments are difficult to take accurately, due to distortion in mounting, different angles of view, and lack of definite points from which to measure. Body size also cannot be accurately measured on mounted specimens. Therefore the length of the cheliceral base was used as an index of size; the validity of this assumption is admittedly open to question. The association between the number of femoral setae and the length of the cheliceral base was tested by Olmstead and Tukey's (1947) Corner Test for Association. Within the species, the two were found to vary independently in most cases. When the mean values for all of the species were used, however, association was significant. Species with longer cheliceral bases tend to have more femoral setae. It is inferred that larger species have more femoral setae. That these two vary independently within the species is also of interest.

The palpal genu is similar in shape in most of the species; it is cylindrical, slightly smaller at the distal end, and about as long or slightly longer than broad. The genu is wider than long in species of *Cheladonta, Pseudoschöngastia,* and *Walchia americana.*

Some of the genual setae are expanded in *Acomatacarus arizonensis, A. plumosus,* and *Whartonia senase.* Certain of the genual setae are distinctive in *Leeuwenhoekia americana.* Dorsal genual setae are occasionally nude in *Speleocola tadaridae, Trombicula crossleyi, T. fitchi, T. kardosi, T. merrihewi, T. montanensis, T. ornata,* and *T. trisetica.*

The number of setae on the genu was handled like that of the femur, and means and standard errors are given in the descriptions of species. No species groups are indicated by these figures but, when considered with the mean number of femoral setae, an interesting relationship emerges. The Leeuwenhoekiinae have a greater mean number of setae on the femur than on the genu, while the trombiculines have either a greater number on the genu than

GRAPH 1: SETAE ON PALPAL FEMUR AND GENU



on the femur or about the same number on the two segments (see Graph 1). This character holds fairly well on individual specimens; of the trombiculines only four individuals were found which had a greater number of setae on the femur, and in these cases the difference was one seta. The Leeuwenhoekiinae, as individuals, have at least four more setae on the femur than on the genu.

As with the femoral setae, the number of genual setae was tested for association with the length of the cheliceral base. Again,

TABLE 3.—Mean Number of Setae on Palpal Femur: Distribution of Species among Taxonomic Categories.

MEAN NUMBER SETAE	Leeuwenhoekiinae	*Eutrombicula*	*Neotrombicula*	other *Trombicula*	*Euschöngastia*	remaining Trombiculinae
3	.....	.....	.....	5	.....	3
4	.....	.....	2	2	3	4
5	.....	1	1	1	2	2
6	.....	1	1	1	.....	1
7	.....	2	.....	.....	.....	1
8	.....	.....	.....	.....	2	1
9	.....	.....	.....	.....	1	.....
10	3	.....	.....	.....	.....	.....
15	1	.....	.....	.....	.....	.....
20	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	.....	.....	.....
30	2	.....	.....	.....	.....	.....
45	1	.....	.....	.....	.....	.....

within the species the two were found to vary independently but between species, using average values, a positive association was present (see Graph 2).

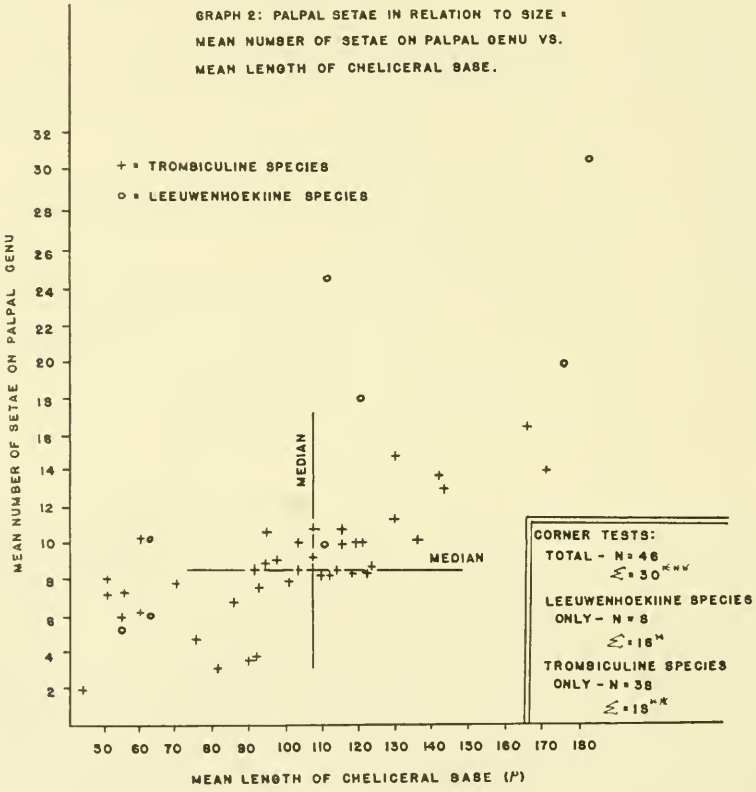
The palpal tibia is a small segment with a distal elongation bearing the palpal claw and the accessory claws. The palpal tarsus articulates to the ventral margin of the tibia. The distal elongation is extreme in *Blankaartia* (figs. 169-172) and is sufficient for identification of that genus. The palpal claw is slightly curved, never divided as in the larvae, and usually about the length of the outer tibial margin. Claws are difficult to compare as to shape, since on the slide a slightly turned claw presents a different aspect. Within a series of specimens gradations from an abruptly tapered claw to an attenuated claw may be seen. The claw appears to be coni-

TABLE 4. Mean Number of Setae on Palpal Genu: Distribution of Species among Taxonomic Categories.

MEAN NUMBER SETAE	Leeuwenhoekiinae	*Eutrombicula*	*Neotrombicula*	other *Trombicula*	*Euschöngastia*	remaining Trombiculinae
3				2		2
4						1
5				2		
6	1					1
7	1		1			2
8			2	3		4
9				1	3	
10	1		1	1	3	2
11	1	2				
12					1	
13		1				1
14		1				
15						
16					1 (*pipistrelli*)	
17						1 (*Blankaartia velascoi*)
18	1					
20	1					
25	1					
31	1					

cal or nearly so, and is always pointed. The claws of *Neoschöngastia* (figs. 100-101, 193-194) are considerably elongated, being more than twice the length of the outer tibial margin. In *Blankaartia* the claws are shorter than the tibia, which is elongated. The accessory claws are at the base of the palpal claw, on or near the dorsal margin and they project medially and forward. The tips of the accessory claws are spatulate; when seen in side view they appear to be sharply pointed but are actually blunt. Most of the species have two accessory claws in tandem, *i. e.*, one behind the other. In *Blankaartia* the number is variable, ranging from two to seven, and the accessory claws are not all in tandem. In *Neoschöngastia americana* the lower accessory claw is absent and a nude or branched seta is present in the same position. In *Neoschöngastia brennani* the lower accessory claw is decidedly smaller than the upper one. Otherwise the two accessory claws appear to be about the same size and length though often they are not parallel and are difficult to compare.

Both the claw and the accessory claws are probably modified setae. There seems to be a gradient of stiffening setae on the dorsum of the palpus which involves the straight femoral setae, the monopectinate setae of the genu and tibia, the accessory claws, and the claw. One specimen of *Speleocola tadaridae* had a branched seta in place of the claw; the substitution of a seta for an accessory claw in *Neoschöngastia americana* has been mentioned.



The medial (inner) surface of the tibia usually bears one branched seta adjacent to the articulation with the palpal tarsus. This seta is lacking altogether in species of *Neoschöngastia* and *Hannemania.* In *Blankaartia alleei, Speleocola tadaridae, Trombicula crossleyi, T. merrihewi,* and *T. trisetica* the seta is often nude. In other species the seta is occasionally duplicated or deleted. Additional setae on the medial surface are regularly found in *Neoschöngastia americana,* where a seta is substituted for the

lower accessory claw, *Chatia setosa,* which has one to three additional setae, and species of *Hannemania,* which have an additional seta below the accessory claws. This latter seta is very stiff and unipectinate with fine branches. Setae on the dorsal margin of the tibia have been counted with those of the lateral surface, although occasionally one appears to be on the medial surface.

Several setae, usually four or five, are present on the lateral (outer) surface of the tibia; these include an apical unbranched seta, stiff unipectinate dorsal setae, and flexible ventral setae. Usually the separation between types of dorsal and ventral setae is not so distinct as on the genu. The apical nude seta is invariably present and rarely with one or two fine branches.

The palpal tarsus is attached to the ventral margin of the tibia; it forms the "thumb" of the chelate apex. The tarsi of the different species have much the same shapes; a narrow, tapered segment, rounded on the end. The tarsus is subject to a large amount of individual variation in shape, to which the mounting process probably contributes. The shape of the tarsus is not sufficiently reliable to characterize the species investigated. The tarsal setae, however, provide several characters.

Typically the tarsus has about nine branched setae, about five apical nude setae, and a striated tarsala. In those species with nine branched setae, the branched setae are remarkably constant in arrangement. On the dorsal margin is a row of three branched setae decreasing in size distally. These setae are strongly unipectinate, with thick shafts and fine branches. The other branched setae have thinner shafts, fewer branches, and are less obviously unipectinate or bipectinate. These are fairly constant in position; two are found on the lateral surface, two on the medial surface, and two on the ventral margin. In the drawings six of the branched setae are included on the lateral surface and three on the medial surface for purposes of comparison. Often it is not possible to tell to which surface the dorsal or ventral setae might belong. Variations in the number of branched setae on the tarsus are frequent since there may be adidtional setae on the lateral surface or lack of lateral or medial setae. Species of *Hannemania* and *Chatia setosa* have up to eighteen branched setae. *Euschöngastoides, Pseudoschöngastia,* and *Walchia americana* have five to seven branched setae on the tarsus. Species of *Neoschöngastia* and *Speleocola tadaridae* have tarsal setae nude or with reduced branching. In *Neoschöngastia* such setae are short and stout.

The tarsala is located on the lateral surface of the tarsus and is probably invariably present. The position of this seta varies within the species from near the base of the tarsus to about the midpoint.

Several short nude setae are present on the tip of the tarsus. These are modified branched setae of the thick-walled type and rarely, tiny branches may be seen. The number and arrangement of these apical nude setae are sufficiently constant for characterization of some species. It is usually possible to refer these setae either to the inner or the outer surface. Those species with five apical nude setae usually have three inner and two outer. Deviations from five apical nude setae were found as follows. Six apical nude setae (four inner, two outer): *Leeuwenhoekia americana.* Four apical nude setae (three inner, one outer): *Euschöngastia criceticola, E. cynomyicola, E. diversa, E. peromysci, E. pipistrelli, Trombicula montanensis,* and *T. myotis.* Three apical nude setae (two inner, one outer): *Acomatacarus plumosus, Speleocola tadaridae, Trombicula crossleyi, T. merrihewi, T. ornata,* and *T. trisetica.* Two apical nude setae (one inner, one outer): species of *Euschöngastoides,* and *Pseudoschöngastia.* One apical nude seta: outer surface, species of *Neoschöngastia;* inner surface, species of *Cheladonta* and *Walchia americana.* Species of *Hannemania* have five apical nude setae arranged four inner, one outer. *Blankaartia alleei* has four apical nude setae, these being two inner and two outer.

Occasional specimens possess one apical nude seta more or less than other members of the species. This variation was noted in *Trombicula whartoni* (five or six setae), *Euschöngastia jonesi* and *E. setosa* (four or five setae), and *Chatia setosa* (six or seven setae).

THE SCUTUM

The scutum of trombiculid mites is a simple plate in the larvae, but in the nymphs and adults it is highly modified. The scutum is probably the most frequently illustrated feature of postlarvae and early descriptions of trombiculids are devoted largely to this structure. The scutum bears the sensilla or pseudostigmatic setae. The exact function of these setae is unknown but they appear to be primarily tactile organs. The modification of the scutum itself, especially the sensillary area, suggests that it has a particular function, however, a thorough study of this structure has never been made.

Usually the scutum is considered to consist of three regions: An anterior tectum, a rodlike crista, and a posterior sensillary area. The tectum is a membranous flap extending from the anterior end of the

crista above the gnathosoma and usually bearing one or two setae. The crista is a heavily sclerotized rod lying on the surface of the integument. Posteriorly, the crista expands into the sensillary area. The sensillary area is a complicated structure, apparently hollow internally, usually strengthened with ridges, and bearing the sensilla at its sides. In the mounting process, the shape of the scutum is usually somewhat distorted, particularly the sensillary area becomes crushed. Also, the scutum but rarely turns on its side, so that a dorsoventral view is most commonly seen. The exact nature of the sensillary area is difficult to make out in this view, but for purposes of taxonomy this position is preferable.

The combination of mounting distortion and dorsoventral expansion of the sensillary area increases the amount of variability seen among mounted specimens. The general aspect of the sensillary area among a series of similar specimens is often quite variable, so that characterization of the scutum for a given species may be difficult. Some previous attempts at separation of similar postlarvae on scutal characters have failed due to this variability. When a characterization is built upon a series of specimens some of the features are found to be relatively constant, but these features must be used with caution. An effort was made to use typical specimens for illustrations, but to handle adequately the variation within a species would require in some cases a drawing for every specimen. In spite of this variation, some features are sufficiently constant as to permit characterization of species and species groups.

The scutum is a relatively simple structure in the leeuwenhoekiine species but becomes more complicated in the trombiculines. The description of this structure may be handled profitably by beginning with the simple types and noting the changes that occur in the more complicated types. This is not intended to be a phyletic sequence except in the most general sense. The elements of phylogeny are certainly involved but the series of examples is not necessarily in the proper order.

The scutum in the Leeuwenhoekiinae (figs. 138-143). These species have scuta which appear intermediate in morphology between the trombiculine species and species of the family Trombidiidae, particularly the subfamily Microtrombidiinae. They differ from the latter in having two tectal setae rather than six or more.

The tectum of the Leeuwenhoekiinae is rather well sclerotized; the margin of the tectum is smooth and never bears serrations or teeth. The tectum is small in species of *Hannemania,* intermediate in species of *Acomatacarus,* and large in *Chatia setosa, Leeuwen-*

hoekia americana, and *Whartonia senase.* In the latter three species the margins of the tectum are heavily sclerotized and the shape of the tectum is somewhat sagittate. In species of Trombidiidae which have such a sagittate, projecting tectum, the term "nase" has been applied to the structure. The tectum bears a pair of setae, usually in the midregion but apically in *Hannemania* and *Acomatacarus.* These setae are not always side by side and seemingly their position may be disturbed by the mounting process. On the single specimen of *Whartonia senase* these setae are almost in tandem. The tectal setae bear short branches and differ from the body setae if the latter are modified. In *Acomatacarus plumosus* (fig. 138) the tectal setae resemble the body setae, being somewhat expanded. In *A. arizonensis* (fig. 142) the tectal setae are not expanded although the body setae are. The tectal setae of *Whartonia senase* (fig. 143) are forked while in *Leeuwenhoekia americana* (fig. 140) they are unusually elongated. The tectal setae are set in pits which may have sclerotized margins. These are particularly evident in *Hannemania dunni.*

The crista is a thin rod with somewhat irregular margins and is readily subject to distortion in mounting. The connection of the crista with the tectum is not always visible. It may be but lightly sclerotized and is sometimes obscured by body setae. The crista is rather broad in *Acomatacarus arizonensis* and *Chatia setosa.* Some punctations may be visible on the crista and are prominent in *Chatia setosa* (fig. 141). The crista appears to be on the surface of the integument, since integumental striations never run over it. Actually the crista may lie in a depressed area; at least that of *Chatia setosa* gives this impression.

Beneath the sensillary area is a continuation of the crista, the basal plate. In the leeuwenhoekiines this plate may be identified as two sclerotized bands, continuous with the crista anteriorly and uniting posteriorly to form a ventral apodeme, which projects behind the sensillary area proper and is mostly subintegumental. The posterior limits of the apodeme are sometimes hard to find. In the illustrations the basal plate is indicated by dotted lines on one side of the sensillary area. The sensillary area is usually wider than the basal plate, but nearly coincides with it in *Acomatacarus arizonensis, Chatia setosa,* and *Leeuwenhoekia americana.* The space between the two bands of the basal plate lies beneath the center of the sensillary area and is oval in *Acomatacarus arizonensis,* and circular to triangular in other species.

The sensillary area proper is on the surface of the integument and is continuous with the crista anteriorly. The center of the sensillary area is a continuous plate which is usually broken in mounting. It may be normally extended dorsally to form a dome-shaped structure which is continuous with the body cavity through the opening in the basal plate. The breaks which are seen on almost all specimens, and which presumably occur during the mounting process, are never regular and vary from specimen to specimen. However, some species show a rather constant structure which may indicate lines of weakness or actual sutures. In *Hannemania eltoni,* an inverted triangle with ridges as borders is seen on most specimens (fig. 139). Whatever the nature of the central part of the sensillary area, the individual variation appears to rule out taxonomic characters.

The shape of the sensillary area is roughly circular except in *Acomatacarus arizonensis,* which has a transverse oval sensillary area. The area is bordered by ridges posteriorly and at the sides; these are irregular in most specimens and are probably also distorted in mounting.

The sensillary bases or pseudostigmata are found at the sides of the sensillary area to midway between the sides and the middle of the area (*Acomatacarus arizonensis, Chatia setosa*). These appear to be conical pits. Around the base of the sensillum itself is a heavily sclerotized ring, and at the outer margin of the pit is a similar larger ring. Between these two are several less distinct concentric circles. Jones (1950:487) has described the sensillum and sensillary bases of the larva of *Trombicula autumnalis.* Their structure is similar to that of the nymphs and suggests their function to be "a sensory perception of touch and probably of vibrations in the air."

The sensilla in the Leeuwenhoekiinae are flagelliform and unbranched. There appear to be no tiny basal branches. The length of the sensilla is not readily measured because the structures are rarely sufficiently straight and because their very fine tips disappear among the body setae. No characters associated with the sensilla were found among species of Leeuwenhoekiinae.

A possible character mentioned by Audy (1954:131) involves "parascutal" setae. These are the body setae which are found at the sides of the crista in front of the sensillary area. Since these setae merge with the other body setae behind the sensillary area, it is not possible to enumerate them accurately in the Leeuwen-

hoekiinae. In *Hannemania* there are about fifty such setae, and in smaller species *(Acomatacarus arizonensis)* about ten or fifteen. These setae are morphologically similar to other body setae, the most anterior of them being slightly smaller. In the illustrations, setal bases beside the crista are indicated and one body seta is figured. Other setae occur lateral to these in the prescutal area.

Puncta are seen occasionally in the sensillary area. They are found in the anterior area in *Chatia setosa* and *Leeuwenhoekia americana* and scattered over the sensillary area in *Hannemania;* other species may show scattered puncta on some specimens.

The scutum in the Trombiculinae (figs. 138-168, 173, 180). In general, scuta of trombiculines differ from those of leeuwenhoekiines in having one or no tectal setae instead of two, in having lateral keels along the crista (in most cases), in having branches on the sensilla (usually), and in having a sensillary area which is structurally more complicated.

Modifications of the scutum in the trombiculine genera allow three types of scuta to be recognized. These are discussed separately below. These types tend to grade into one another but the division is of use in the discussion.

"Type A" is possessed by *Euschöngastoides hoplai, E. loomisi, Pseudoschöngastia farneri, P. hungerfordi,* and *Walchia americana* (figs. 144-147). These species have a scutum with a rather short crista and a broad sensillary area which is less complicated than the following two types.

The tectum is broad and short in all but *Walchia americana,* which has an almost square tectum. Species of *Pseudoschöngastia* lack serrations on the tectum. Small serrations are present on the anterior border of the tectum in species of *Euschöngastoides,* and large, long serrations are found on the tectum of *Walchia americana.* The tectal seta is lacking in *Walchia americana* and is very short in the other species. Branching is much reduced in all except *Euschöngastoides hoplai.* The connection of the crista with the tectum, and the posterior portions and corners of the tectum, are difficult to see in these species, except for *Walchia americana.*

The crista is a rather narrow, heavily sclerotized rod. Lateral keels (Brown, 1952:20) appear to be present in all species. These are flaplike, membranous structures lying beside the crista; they are invariably displaced during the mounting process so that their exact position is not known. Apparently they parallel the crista on

each side and connect posteriorly with the sides of the bulla (see below). Lateral keels were not visible in all specimens, and usually only portions of them could be seen. They are most clearly visible in *Walchia americana.*

The crista joins the sensillary area and immediately divides into two arms which run laterally at right angles to the crista. These form the anterior margin of the basal plate. Among scuta of this type the basal plate consists of two halves lying approximately under the sensillary bases. In *Euschöngastoides* the plates also appear to have a thin posterior connection. The basal plate contains openings for the sensillary bases. The shape of the basal plate is slightly different among the three genera, the anterior parts being somewhat difficult to see. At the anterior portion of the sensillary area a somewhat triangular structure occurs, which has its apex on the posterior part of the crista and its base in the middle of the sensillary area. The term "bulla" seems appropriate for this structure, since it seems to be hollow and domelike, and expanded dorsally. The bulla is continuous with the crista anteriorly; small ridges or bars connect the corners to the sides of the sensillary area; and the lateral keels appear to be attached at these corners. The posterior margin is convex and is usually irregular. The sensillary bases are similar to those of the leeuwenhoekiine species; they are located at the lateral extremes of the sensillary area. Ridges encircle the sensillary area, running from the sides of the bulla around the sensillary bases and along the posterior margin of the area. These ridges are irregular in shape and are often broken and displaced in mounting. In *Walchia americana* the major ridges pass medial to the sensillary bases instead of around them; small ridges are found lateral to the sensillary bases. Also, in *Walchia americana* the posterior ridge is discontinuous and connected by a small secondary ridge at the midpoint of the posterior end of the area. Body striae enter the sensillary area over the anterior ridge, passing between the bulla and the sensillary bases; the striae are continuous through the depressed area behind the bulla but do not cross the posterior ridge. The posterior apodeme was clearly seen only in *Walchia americana,* where it is much reduced.

All of these genera have sensilla with branches. In species of *Euschöngastoides* the sensilla have very minute branches on their extreme basal portions; these are followed by longer branches for about half the length of the sensillum. The distal half is provided

with much longer attenuate branches. The stem of the sensillum is long and attenuated; near its apex it becomes zigzag in most specimens (fig. 146). Branches arise from at least two planes of the sensillum. The sensillum of *Walchia americana* is similar to that of *Euschöngastoides* but the stem is somewhat thicker and straighter. The sensillum of *Pseudoschöngastia farneri* has a rather thick straight stem, with short basal branches, long attenuate branches in the midregion, and shorter attenuate branches at the apex (fig. 145). The medial branches have enlarged bases, giving the stem a slightly irregular appearance. The sensillum of *P. hungerfordi* is similar to that of *P. farneri* but is usually somewhat expanded medially, presenting a subclavate appearance (fig. 144). Occasional specimens of *P. hungerfordi* have the sensillum very little expanded or not at all, so that it alone would not serve to separate the two species of *Pseudoschöngastia.* One series of *P. hungerfordi* contained no specimens with expanded sensilla.

Scutal punctations are occasionally present but never numerous in the sensillary area or on the crista.

The parascutal setae are much less numerous than in the leeuwenhoekiine species. Usually they appear to be relatively distinct from the other body setae due to their decreased density. Precise enumeration is difficult; six to fourteen parascutal setae were noted among these species, except for *Walchia americana.* This latter species consistently has but a single pair of parascutal setae. This appears to be a sound taxonomic character as no specimens of other species were found with but two parascutal setae.

The two remaining types of scuta are similar to each other. "Type B" includes species with sensillary bases rather far forward in the sensillary area and the central portion of this area reduced, so that the sensillary area has a reniform shape. "Type C" includes species with the sensillary bases at the middle or back of the sensillary area with the central portion of this area modified and prominent, the appearance of the sensillary area being triangular or transverse. The distinction between these two types, while not clear-cut, is one of convenience.

Species possessing "Type B" scuta are *Cheladonta micheneri, C. ouachitensis, Neoschöngastia americana,* and *N. brennani* (figs. 149, 154-155, 180). In these species the tectum is provided with serrations or teeth; these are long in species of *Neoschöngastia* and short and broad in species of *Cheladonta.* The tectal seta is longer than the body setae.

The crista is rodlike and plainly connected to the tectum. Lateral keels are present although distorted and often difficult to see. The crista broadens before it reaches the sensillary area in *Cheladonta;* in *Neoschöngastia* the crista reaches the sensillary area before broadening.

The basal plate of the sensillary area in these species arises as a furcation of the crista. In *Cheladonta* (fig. 154) it consists of two bands passing posteriorly beneath the sensillary bases; an opening in the basal plate is found beneath each sensillary base. The basal plate of *Neoschöngastia* (fig. 180) is similar but has a larger, drop-shaped opening for each sensillary base. In *Neoschöngastia* the basal plate appears to terminate at the posterior margin of the sensillary area; the apodeme is either much reduced or absent. The basal plate of *Cheladonta,* however, plainly continues posteriorly to the sensillary area as an apodeme formed from the union of two bands. The apodeme is broad, often marked with irregular openings and often furcate posteriorly.

The bulla of the sensillary area is somewhat reduced in size in *Cheladonta* but still triangular in shape; in *Neoschöngastia* the bulla is much reduced and is hardly wider than the crista in *N. americana.* Ridges from the corners of the bulla pass laterad to the sensillary bases and unite at the back of the sensillary area. In *Neoschöngastia* additional ridges pass medial to the sensillary bases. These ridges are variable in shape and position, apparently due to distortion in mounting. Body striae enter the depressed area behind the bulla from the anterior angles of the sensillary area. Body striae also surround the sensillary bases but do not cross the posterior ridge of the sensillary area.

Punctations are present on the posterior part of the crista and in the sensillary area.

The sensilla are provided with branches, which are tiny on the basal portions and become longer distally. In *Cheladonta michaeneri* they are subclavate in shape; in *C. ouachitensis* they are slightly expanded in their midregions but taper again in the distal portion. The sensilla of *Neoschöngastia americana* are similar but slightly expanded distally, and with short branches on the basal half.

Parascutal setae are similar to the body setae but less dense, numbering about ten.

A "Type C" scutum (sensillary area triangular rather than reniform) characterizes the genera *Blankaartia, Euschöngastia, Speleocola,* and *Trombicula* (figs. 4, 148, 150-153, 156-168, 173). These

genera include about one half of the species in this study. The "Type C" designation is essentially a category for those scuta without unusual modifications.

The tectum is square or triangular in most species; the margin of the tectum is smooth in *Blankaartia* and *Euschöngastia* but provided with serrations or teeth in *Speleocola* and *Trombicula.* In most species the teeth number about eight to twelve; often they are difficult to see and counts seem to be impractical but the presence or absence of teeth usually can be ascertained without difficulty. In the subgenus *Eutrombicula* the teeth are smaller and more numerous, averaging about twenty. A slight central prolongation of the tectum is present in species of the subgenus *Neotrombicula* and in *Trombicula ornata.* A single tectal seta is present in all species; occasionally it is duplicated and in these cases the two setae are in tandem. The tectal seta tends to be elongated in most species of *Euschöngastia.*

The crista is a narrow rod, often of irregular width. Lateral keels were seen in all species except *Blankaartia velascoi;* these are invariably disturbed in mounting and their terminations are obscured.

The sensillary area may be roughly characterized as a transverse oval in most *Euschöngastia,* compared to a triangular shape in the other species. The basal plate is composed of two halves, formed by a furcation of the crista anteriorly; the posterior termination is difficult to see but apparently the two halves are united beneath the posterior ridge. The plate contains openings for the sensillary bases (these are omitted from the illustrations). As with the previous species, the basal plate is indicated on one side of the illustrations by dotted lines. The shape of the central opening of the basal plate may be a useful character for separating some species. The apodeme may be seen as an extension of the basal plate in most *Trombicula* but is reduced to a tiny isolated piece in *T. crossleyi, T. merriheui, T. ornata, T. trisetica,* and species of *Euschöngastia* except *setosa.*

The bulla is present in all species and is essentially the same shape in most species; an expanded triangular structure at the anterior portion of the sensillary area. The bulla is reduced in size in *Euschöngastia diversa, E. peromysci, Speleocola tadaridae,* and *Trombicula myotis;* the bulla is elongated anteriorly in species of *Blankaartia.* A median carina is present atop the bulla. This structure is usually flattened in mounting and may be obscured or confused with the walls of the bulla; apparently all of the species

have a carina but it is not always seen. The carina is thickened in some species, particularly in the subgenus *Neotrombicula*. In this group the carina appears to be a thick, slightly elevated structure but may actually be absent. In occasional specimens of many species the carina is doubled at the posterior end.

The sensillary bases have the same structure as described for the other types of scuta. The bases are placed well at the sides; they appear slightly enlarged in *Trombicula crossleyi, T. montanensis, T. merrihewi,* and *T. trisetica.* This may be a function of the small size of these scuta.

The sensillary area is surrounded by ridges, which include weak ridges from the angles of the bulla, heavy ridges around the outsides of the sensillary bases, and a rather weak posterior ridge. The ridges encircling the sensillary bases have elevations in front of and behind the bases. A crossbar may usually be found medial to the sensillary base but is usually weak and often distorted. In *Speleocola tadaridae* these crossbars are strong and have elevated flanges on them (fig. 173). Additional crossbars are found irregularly on some specimens. The posterior ridge is usually broken in mounting. In species of the subgenus *Eutrombicula* this ridge has a bilobed appearance caused by two elevated areas, a condition indicated in *Trombicula gurneyi.* Body striae enter the sensillary area at the front, between the bulla and the sensillary bases, while a few striae appear to cross the ridges around the sensillary bases. Striae do not cross the posterior ridge.

On the margin of the sensillary area, near the angles of the bulla, one or two tiny projections may be seen. These are apparently subcutaneous and are inconspicuous except in the genus *Euschöngastia.* In species of *Euschöngastia* (except *E. trigenuala*) these projections are enlarged into rather conspicuous teeth. The limits and extent of the teeth are difficult to make out, owing to confusion with body striae and with lateral keels. Their exact nature is not known.

The sensilla afford usable characters in this group of species. In species of *Blankaartia* the sensilla are long, attenuated, and entirely nude. Sensilla of other species have, at least, tiny basal branches. Species having sensilla which are rather thick but not subclavate and provided with short branches along the entire length include *Euschöngastia cricetícola, E. cynomyicola, E. diversa, E. peromysci, E. pipistrelli, E. setosa, Trombicula autumnalis, T. fitchi, T. lipovskyi,* and *T. sylvilagi.* Sensilla of this type

but with a reduced number of branches are found on *Euschöngastia jonesi* and *Trombicula kardosi.* The sensillum of *Euschöngastia trigenuala* is similar but lacks branches on the distal third of its length. The sensillum of *Trombicula whartoni* is similar in being rather thick but not subclavate, but lacks branches except for minute basal ones. Species having sensilla slightly expanded distally, or subclavate, and provided with rather heavy branches include *Speleocola tadaridae, Trombicula crossleyi, T. merrihewi, T. ornata,* and *T. trisetica.* Sensilla which are flagelliform, having thin stems, and provided with long fine branches are possessed by *Trombicula belkini, T. gurneyi,* and *T. kansasensis;* similar sensilla with numerous fine branches are found on *T. montanensis* and *T. myotis.* Species with similar sensilla but which have the branches less numerous and arising from a single plane include members of the subgenus *Eutrombicula,* except *T. belkini.* In the subgenus *Neotrombicula,* many specimens have sensilla with furcations at the tip; these are rather small and appear to be two normal branches rather than an additional modification of the stem.

A few puncta may be seen in the sensillary area on most specimens. Puncta are exceptionally numerous on species of the subgenus *Eutrombicula* (except *T. belkini*), *Trombicula lipovskyi,* and *T. whartoni.*

Parascutal setae were found to be difficult to count precisely; most species have about eight to fourteen such setae except for members of the subgenus *Eutrombicula,* which have about twenty to thirty, and species of *Blankaartia,* which have about thirty. Except for these extreme cases, the number of parascutal setae would be a difficult character to apply. In *Trombicula crossleyi* and *T. trisetica* a pair of parascutal setae is placed directly in front of the sensillary area, one seta on either side of the crista. These setae are noticeably longer than the other parascutal setae. *Trombicula ornata* has two parascutal setae in the same position which are but slightly longer than the other parascutal setae. In other species, there are usually no setae in this position.

Measurements of the scutum. A series of measurements of the larval scutum has been used successfully for some years. Workers on postlarval stages have taken various measurements of the scutum but there has been no general agreement as to what to measure or how the measurements are to be taken. Audy (1954:128) has proposed an ambitious scheme for taking eleven measurements of the scutum; his system includes the better ideas of other workers but is

still affected by an underlying difficulty, in that the nymphal scutum has few definite points from which to originate or complete a measurement. The larval scutum, in contrast, has five or six scutal seta in addition to the sensilla, and the larval measurements are based upon these definite points.

Both the anterior and the posterior margins of the sensillary area are indefinite; the anterior margin is marked by the gradual widening of the crista, and the posterior margin by the very irregular posterior ridge. Thus it seems that measurements of the length of the crista itself, the length of the sensillary area, the length of the posterior apodeme, or others involving these points would prove impractical. The writer has taken only four measurements, as follows: ASL: Anterior scutal length, measured from the tectal seta to the level of the centers of the sensillary bases. SB: Distance between sensillary bases, measured from the point of insertion of the sensilla. TS: Length of the tectal seta(e). SENS: Length of the sensillum. The ratio ASL/SB provides a quantitative expression of the general scutal shape.

The debatable measurement here seems to be the measurement ASL. The anterior point used could have been the anterior termination of the crista rather than the tectal seta. However in many species the measurement cannot be taken with the oil immersion lens, and the tectal seta is visible under lower magnification although the anterior termination of the crista may not be. At lower magnification it is easier to determine the posterior limit of the measurement; the ocular scale used by the author had long rulings which often spanned the distance between the two sensillary bases. A further difficulty arises in the genus *Walchia,* which lacks a tectal seta. For the single species included in this work, the measurement was taken to about the middle of the tectum (a procedure suggested by the position of the tectal seta in *Pseudoschöngastia*). Workers in the Asiatic Pacific area have to contend with many species of *Walchia* and may well find this procedure objectionable.

Accurate measurements of the lengths of the sensilla are impossible except in the species where they are thickened and straight. In other species estimates of the length were made.

The measurements ASL, SB, and TS are given in the descriptions of species. The measurement ASL is roughly related to the size of the mite and has a large standard error. The measurements SB and TS are rather more independent of size and have smaller standard errors. However, all three of these measurements may be used to separate some species from others, and as such, they provide usable taxonomic characters.

The ratio ASL/SB is also given in the descriptions of species. In table 5 the distribution of this ratio among taxonomic categories is given. This table shows that three general groups are formed: A lower group with mean ratios between 1.2 and 1.7, a central group with mean ratios between about 1.9 and 3.0, and an upper group with mean ratios from about 3.2 to 5.2. The upper group is composed of leeuwenhoekiine species, but members of the genus *Blankaartia* approach them. The lower group is composed of *Euschöngastoides*, *Pseudoschöngastia*, and *Walchia* (species with a "Type A" scutum). Most species fall into the middle grouping. It is further seen that the generic groupings are fairly distinctive. As more species become known, it may develop that the ratio ASL/SB is a valuable generic character.

THE BODY

This section considers the body and its morphological features not previously treated, namely the setae, eyes, sternum, genitalia, and anus.

Shape. Body shape has been frequently used to characterize trombiculid postlarvae. A classic method for separating trombiculids from their relatives was by body shape; trombiculids were be-

TABLE 5. The Ratio ASL/SB: Distribution of Species among Taxonomic Categories. (ASL and SB are explained in text.)

MEAN RATIO	Leeuwenhoekiines	*Eutrombicula*	*Neotrombicula*	other *Trombicula*	*Euschöngastia*	*Pseudoschöngastia*	*Euschöngastoides*	remaining trombiculines
1.2							2	
1.4								1 (*Walchia*)
1.6						2		
1.8								
2.0					1			1
2.2			3	4	2			2
2.4		1	1	2	1			1
2.6		2		4	4			
2.8		1						
3.0								1 (*B. alleei*)
3.2	1 (*A. arizonensis*)							1 (*B. velascoi*)
3.4								
3.6	1							
3.8	1							
4.2	1							
4.5	2							
5.2	2							

lieved to have a constriction of the body which produced a "figure 8-shape," while trombidiids lacked such a constriction. Subsequently it was discovered that leeuwenhoekiine genera (except *Hannemania*) lack the constriction; however, all known trombiculine species are constricted. This feature is often destroyed in mounted material and must be used with caution except in fresh or alcoholic material. Another difficulty in applying the body constriction as a diagnostic character separating trombiculids from trombidiids is the presence of slight constrictions in some trombidiid species. The body shape of leeuwenhoekiines (except *Hannemania*) is a slightly elongated oval (fig. 205). Most trombiculines have a rounded "figure 8-shape" (fig. 202) except for certain species which are noticeably elongated; these are species of *Cheladonta* (fig. 200), *Pseudoschöngastia, Trombicula autumnalis, T. crossleyi, T. merrihewi, T. sylvilagi,* and *T. trisetica* (fig. 1). An elongated body has been suggested as a possible character for *Neotrombicula* but this is not a feature of all members of that subgenus. The body is shortened and strongly constricted in species of *Neoschöngastia* (fig. 201).

Size. As previously mentioned, body size of nymphs is not subject to exact measurement due to extreme distortion in mounting. This is less true of the smaller species than the larger ones; nevertheless, most specimens could not be measured with any feeling of accuracy. Estimates of the body length were made only to tenths of a millimeter; these are given in the descriptions. The range of sizes found was from 0.4 to 1.2 mm. Most of the species are between 0.6 and 0.8 mm. long; species measuring 0.5 or less were characterized as "small" (seven species); those measuring 0.9 or larger were characterized as "large" (nine species). No estimates of width were made.

Eyes. The presence or absence of eyes, and their number and position, is a much-used character in mite taxonomy. Eyes of trombiculids are bright red in life but are sometimes difficult to see in mounted material. Most species lack eyes. Of the leeuwenhoekiinae species, all have eyes except *Acomatacarus arizonensis* and *Whartonia senase*. The eyes are found in front of the sensillary area at the sides of the propodosoma or nearer the crista. The eyes are double (2/2) in species of *Hannemania* but are single (1/1) in other species. Of the trombiculine genera, eyes are found only in the genus *Blankaartia* where they are single and placed as in the leeuwenhoekiine species, and in the subgenus *Eutrombicula* where they are single and placed adjacent to the sides of the sensillary

area. In *Blankaartia* the eyes are distinct ovals; in *Eutrombicula* they are less distinct and sometimes have a semilunar appearance, owing to their proximity to the sensillary area. The eyes are clearly visible in *T. alfreddugèsi* and *T. splendens,* but hard to see in *T. belkini* and *T. lipovskyana.* Particularly in *T. belkini,* the presence of eyes is detected in mounted specimens only by the disruption of the cuticular striae. A lens could be seen clearly only in one specimen of *belkini* examined in this study.

Observations on living material in culture disclosed no obvious differences in behavior between species lacking eyes and species possessing them. Species lacking the lenses may well have light-sensitive areas which are not detected in cleared and mounted material.

Setae. A dense coat of body setae is characteristic of the group of mites to which trombiculids belong. Characters involving body setae have been very successfully used among these mites. Typically body setae are branched and so numerous as to form a thick pelage which obscures the integument and even features of the setae themselves. The dorsal setae are somewhat longer and thicker than the ventral ones; those of both surfaces increase in length posteriorly, so that the longest are the posterior dorsal ones. Posterior setae typically arise from tubular elevations each of which is supported by a small circular platelet. The ventral and the anterior dorsal setae arise from less distinct platelets and are but slightly elevated.

Body setae are best observed at the posterior margin of the body. Posterior dorsal setae have been figured for most species. In the following discussions distinct types will be mentioned but not described in detail, since the illustrations better fulfill this purpose.

Primitive body setae are probably the types with simple attenuated stems and simple branches; however, of the leeuwenhoekiine species only *Chatia setosa* has such setae. Among the trombiculines most species have unmodified attenuated body setae although the stem may be shortened or lengthened, and the tip of the stem may be modified. Body setae with straight but thickened stems are found in *Hannemania* and some species of *Trombicula.*

A usual type of tip found on the posterior body setae is a division of the attenuated stem into two or three short branches. Modifications of the tips are often so constant as to form valuable generic or specific characters. *Chatia setosa* and *Euschöngastia pipistrelli* possess body setae with single, very long, attenuated tips. Species of *Hannemania* have body setae which terminate in a curved, al-

most hooklike spine. Body setae of *Trombicula myotis* terminate in hyaline knobs. Very tiny branches are found in groups at the tips of the body setae of some species, including *Euschöngastoides loomisi, Walchia americana,* some species of *Trombicula,* and particularly some species of *Euschöngastia.* In the latter genus a transition may be seen from a seta with a simple tip (*E. criceticola*) through one with short branches on the tip (*E. diversa, E. setosa*) and a seta with the stem and its tiny branches offset at the tip (*E. jonesi*) to a seta with many tiny branches over the tip and even distributed along a dominant lateral branch (*E. peromysci*). Relatively small branches are found near the tips of setae of most species of *Trombicula.*

Modifications of the usual shape of the setae include the peculiarly expanded setae of *Acomatacarus* and *Cheladonta,* and the leaflike setae of *Whartonia senase.* Compound branching is found in the setae of species of *Neoschöngastia* and *Speleocola tadaridae.* The setae of *Trombicula fitchi* are peculiar in the arrangement of the branches; long branches are found on the basal half but only short, thick-based branches occur on the distal half. Setae of *T. kardosi* are similar to these but occasional long branches are found among the shorter ones.

The increase in length posteriorly is usually a gradual transition, but in *Euschöngastia pipistrelli, E. trigenuala,* and *Trombicula fitchi* the change is abrupt; posterior setae are strikingly longer than the adjacent dorsals. Intermixed long and short body setae are found on *Acomatacarus arizonensis* and species of *Neoschöngastia.*

The lengths of various body setae have been used as specific characters with some success. Certain difficulties arise, however, when measurements of these setae are attempted. Modifications of the tip often make the exact termination of the seta obscure; lateral branches may exceed the tip of the stem in length and these are so flexible that only an approximate length can be obtained. Setae which end in fine tips cannot be measured accurately. Even the relatively unmodified setae can be exasperating in this respect. The writer found it impossible to obtain the same figures in remeasuring setae of *Trombicula alfreddugèsi* and *T. splendens.* Authors have recommended the measurement of setae from various parts of the body, but since the setae increase in size posteriorly, these measurements are useless unless the exact location of the seta is specified. The writer measured only posterior body setae; these figures are given in the descriptions as approximations. A

continuous range of values was found from about twelve to about one hundred and five microns. Variation among individual specimens seems to be about twenty microns in the species with larger setae and less in those with smaller ones. The central posterior dorsal setae on a single specimen appear to show less variation than occurs between individuals. All in all the length of the posterior body setae is a usable character if not too strictly applied; species towards the extremes may be separated easily from others but species with setae of similar length should be compared with caution as to this character.

Sternum. The sternal area lies between the coxae of legs I and II. Recently Womersley (1952:18) found several taxonomic characters associated with the sternum. Some species (*Guntherana*) have precoxal plates of coxae I present, other species (*Trombicula,* subgenus *Leptotrombidium*) have these precoxal plates of coxae I fused to form a longitudinally divided sternum, and most species (most *Trombicula*) have the longitudinal division obliterated so that a sternal area remains which is closed behind by a crossbar connecting coxae II. In *Gahrliepia* (= *Walchia*) Womersley found no evidence of a closed sternum formed by fusion of precoxal plates.

Of the species in the present work, only *Neoschöngastia* was found to have precoxal plates (fig. 177). (Womersley, 1952, included descriptions of three species of *Neoschöngastia* but did not mention the sternum.) A longitudinally divided sternum is present in *Trombicula (Leptotrombidium) myotis,* which agrees with Womersley's findings.

The sternum in the leeuwenhoekiine species consists of a sclerotized plate bearing eight or ten setae. In the other (trombiculine) species the sternum is closed behind by a bar connecting the coxae of legs II, with certain exceptions. *Speleocola tadaridae, Trombicula crossleyi, T. merrihewi* (fig. 181), *T. ornata,* and *T. trisetica* have sternal areas which are elongated posteriorly and open behind; however, some specimens show a very weak incomplete bar between the coxae II. Apparently the closure has been secondarily lost in these species, perhaps as a consequence of change in shape of the sternal area or decrease in general size. Other species have a sternum of pentagonal to rectangular shape (or elongated in *Euschöngastia jonesi* and *Walchia americana*) which is closed behind, although the posterior bar is weak in some species and sometimes is incomplete. (*Walchia americana,* in contrast to Womers-

ley's observations on that genus, has a closed sternum.) Occasional specimens (particularly specimens of *Cheladonta* and *Walchia americana*) show a trace of a longitudinal division of the sternal area. This would seem to lend support to Womersley's suggestion that the closed sternum is derived from fused precoxal plates. However, some leeuwenhoekiine species have a posterior thickening of the sternal plate which resembles the closure of the trombiculine sternum.

Setae on the sternum are usually of the ventral body type (but different in *Acomatacarus* and *Whartonia senase*). About eight setae are usually found in the sternal area; larger species have about twelve setae and smaller ones about four to six. The setae were not counted on all specimens but the variation noted was large (about six to fourteen sternal setae in *Trombicula splendens*).

Genitalia. The genital opening (fig. 12) is located between or immediately behind coxae IV. The genital areas of all species resemble one another very closely. Most external is a pair of elongated plates which bear branched setae similar to those of the body; the genital opening is between these two plates. Mesal to these, and extending across the genital opening, is a pair of elongated plates which bear the three pairs of genital setae. These setae (figs. 13-15) are invariably six in number and are usually nude but occasionally forked or branched. Rarely one or two of the genital setae resemble the fanlike genital setae of the adult male (see fig. 15). This phenomenon may be the expression of an adult character in the nymphal stage, but it would appear that sex is not consistently expressed in the nymphs in this manner since very few specimens show this character. The two pairs of genital suckers are located beneath the plates in the midregion of the genital area. Their function is unknown. Their size appears to be variable, and their relative size was found to be inconstant in a series of specimens.

Anus. The anus is located posterior to the genital opening. The anal opening itself is not evident; the term "anus" is applied to the plate or plates guarding the presumed position of the opening. In the leeuwenhoekiine species (fig. 197) the single anal plate is circular or oval, poorly sclerotized, not obviously divided, and usually distorted in mounting. The anal opening of trombiculine species (fig. 199) is obviously guarded by two elongated shoelike plates, each of which bears a number of setae. No further characters associated with the anus were found.

LEGS

Characters involving the legs of trombiculid postlarvae have been virtually ignored, probably because of the plethora of setae found on them. In the classification based on larvae, features valuable in taxonomy include the number of leg segments and the number of modified setae on certain segments.

All of the species included in the present study have, as nymphs, seven segments in the legs; these are coxa, trochanter, basifemur, telofemur, genu, tibia, and tarsus. A pretarsus, consisting of a pair of claws, is present on the tarsus of each leg. Except for several exceptions the relative shapes of the various segments appear to be the same for all species. Leg setation, also, is very similar among the various species. Therefore the following discussion will be general, particularly in regard to leg setae.

Usually the legs are slightly shorter than the body, leg I being the longest and largest. In *Chatia setosa* (fig. 190) the legs are noticeably elongated, leg I being obviously longer than the body and the other legs about as long as the body. Legs appear slightly shortened in some species and particularly in species of *Cheladonta,* but others (*Euschöngastoides, Neoschöngastia, Pseudoschöngastia,* and some *Trombicula*) approach this condition. The coxa is a rather flat, cylindrical segment which appears to be slightly movable. The trochanter is a small, somewhat arched segment. Articulations between coxa and trochanter and between trochanter and basifemur are dicondylic; the former permits dorsal-ventral movement and the latter anterior-posterior movement of the more distal segments. Articulations between remaining segments are monocondylic and dorsal. The distal segments are cylindrical, about as long or longer than broad. Shape of tarsus I appears distinctive for certain species, these being the somewhat pyriform tarsi of *Acomatacarus* and *Whartonia senase* (figs. 187, 189), and the rather rounded tarsus of *Cheladonta* (fig. 184). Otherwise tarsi are generally similar in shape. *Walchia americana* possesses a short stump which projects from the distal dorsal portion of tarsus I (fig. 188).

Two measurements were taken on tarsi I, these being the length (TL), measured from the dorsal articulation to the ventral tip, and the thickness (TH), measured at the widest point. The ratio TL/TH was computed. These figures with their standard errors are given in the descriptions. Generally the size of the measurement reflects the size of the mite. The ratio TL/TH has

a rather small range among most species; however, the standard error is small and this character is useful in separation of some species. No groups of species were distinguished either by the measurements or by the ratio.

Leg segments, especially the more distal ones, are covered with setae. While the number of nude or branched setae on a segment is constant for the species in many larvae, the number of both types varies among specimens of postlarvae. Audy (1954:128) has proposed a scheme for tabulating the number, type, and location of leg setae. The writer used a somewhat simplified modification but abandoned the project as being laborious and unproductive. All in all, the tabulation was completed for six species; the following description is based upon this information and upon less precise observations on the other species.

Interspecific variation in the number of setae per segment was found in all species and on all segments. Coxal setae resemble the ventral body setae; straplike extensions of the coxae I extend towards the dorsum and these bear elongated setae. The trochanter bears branched setae which are elongated and placed in a band across the segment; the number of setae found was three to five on the smaller species and seven to nine on the larger ones. Branched setae on the remaining segments become increasingly modified distally; the setae become unipectinate and the branches become straight and increasingly fine. Setae on the tarsus may be described as comblike. Branched setae on the legs are slightly expanded in species of *Acomatacarus, Leeuwenhoekia americana,* and *Whartonia senase.* Nude setae first appear on the telofemur, which has zero to two dorsal nude setae. The remaining distal segments have increasing numbers of nude setae, particularly on leg I. On tarsus I nude setae are extremely numerous. On the remaining leg segments the nude setae do not become so numerous and can be counted. The genu and tibia have about six to fifteen dorsal nude setae. The tarsi of legs II, III, and IV have fewer nude setae and occasionally lack nude setae altogether.

Audy (1954:128) distinguished several types of nude setae, from blunt, striated, nearly flask-shaped setae to attenunated, unstriated setae, and noted the occurrence of microsetae. These types (except microsetae) tend to grade into one another in the material examined by the writer. Nude setae of the more proximal segments tend to be unstriated and attenuated, although blunt striated setae are not excluded. Tarsi II, III, and IV usually have at least one

long untapered striated seta reminiscent of the tarsala of the larval stage; however, the seta may be absent and often more than one is present. Another feature of these tarsi is a slight recurved seta on the dorsal distal margin, which resembles the subterminala of the larval tarsi I. These setae are not at all constant in occurrence. Variation in nude setae appears to be of such magnitude as to require a precise tabulation such as that proposed by Audy, if characters involving these setae are to be found.

Useable characters no doubt exist in leg setation but the most likely ones appear to be those involving counts of setae on the more proximal segments, rather than features of the types of nude setae. At any rate a considerable amount of laborious tabulation is needed before these features can be utilized.

RELATIONS OF MORPHOLOGY TO HABITS AND ENVIRONMENT

Little is known of the habits and natural habitats of postlarval trombiculids, since the postlarval stages are not often collected. Loomis (1956), however, gives what he believes to be the habitat of the postlarval stages for most of the species considered in the present paper.

Trombiculid postlarvae are dwellers in soil or in similar substrates. The habitats suggested by Loomis include grassland and woodland soils, mammal nests or burrows (and soil associated with these), decaying wood, crevices in rocky outcrops, and bat caves. Quite possibly all of these habitats provide a substrate of similar physical conditions (perhaps a somewhat granular substrate in which the mites can burrow) so that little adaptation to the physical makeup of the substrate of different habitats is needed. At any rate there are no consistent morphological differences between species in different habitats. Species which occur in decaying logs (*Trombicula splendens,* for example) may be morphologically similar to close relatives which occur in soils (in this case *Trombicula alfreddugèsi*). Larvae of *Trombicula merrihewi* have been taken only from bats, and larvae of *T. ornata* have been found only on rodents, yet the nymphs of these two species are quite similar. From this it appears that the postlarval habitat as suggested by larval host preferences, does not provide sufficient information to permit conclusions concerning the relationships of morphology to habitat.

Additional information is available from seasonal occurrence and observations on cultures. Since some species show marked differences in seasonal abundance in the larval stage, it may be assumed that their postlarvae have different temperature requirements and tolerances. Within the genera *Trombicula* and *Euschöngastia,* nymphs of winter species of chiggers tend to have stouter cheliceral bases and wider cheliceral blades than do nymphs of summer chiggers. There are some exceptions to this tendency. It seems unlikely that this modification is directly associated with temperature tolerances.

Observations on cultures indicate that nymphs of similar species have different humidity requirements (Wharton and Fuller, 1952: 149). If there is a relationship between morphological features and humidity requirements in trombiculid nymphs, it is not an obvious one. The postlarvae of *Whartonia senase* seemingly occur in very dry habitats, and their leaflike body setae possibly provide protection against dessication. Such modifications are not seen among other nymphs which may inhabit very dry situations. Species of *Hannemania* and of *Blankaartia,* whose postlarvae must exist in very moist habitats, show no features which are clearly adaptations to such environments.

Gross culture observations disclosed no differences in behavior between postlarvae which have eyes and those which lack eyes. Nevertheless, it happens that those postlarvae which are not uncommonly collected in the field are those which have lenses *(Blankaartia* in Panama and *Eutrombicula* in many regions); possibly these species more readily come to the surface and are detected by collectors. This does not hold true for species in the subfamily Leeuwenhoekiinae, nymphs of which usually have lenses but are not commonly collected.

The food material taken by nymphs in culture offers additional information concerning their habits. Although data are not available for all species, the general picture is as follows. Insect (Collembola) eggs only: *Euschöngastia, Trombicula* (and probably *Blankaartia* and *Speleocola*), and *Hannemania.* Collembolans only: *Cheladonta, Neoschöngastia, Pseudoschöngastia,* and *Walchia.* Did not feed: *Euschöngastoides.* Information is inconclusive for the remainder of the genera (all leeuwenhoekiines). Some specimens of *Trombicula* occasionally eat active collembolans.

Those species which eat active prey show gnathosomal modifications possibly associated with their food habits. The genera

Cheladonta and *Neoschöngastia,* particularly the former, have elongated gnathosomal elements which possibly assist in the capture of prey. The genera *Pseudoschöngastia* and *Walchia,* however, have shortened gnathosomal elements. These latter genera have a more heavily sclerotized pharynx with reticulate markings, which suggests more powerful musculature.

COMPARISON OF LARVAL AND NYMPHAL MORPHOLOGY

This section includes an abbreviated account of larval morphology for comparison with the nymphal morphology. Emphasis is placed upon those forms for which the nymphal morphology is described. More detailed accounts of larval morphology may be found in Wharton and Fuller (1952:30) and, for Kansas materials, in Loomis (1956:1223).

The larva is six-legged rather than eight-legged but otherwise is essentially similar to the nymph in gross morphology. The body is at most only slightly constricted; it is capable of distention during engorgement. There is no closed sternum between legs I. The genital opening is absent. The scutum is not modified into a linear stricture but retains its platelike nature. Rarely caudal plates are present on the posterior dorsum of the abdomen.

The cheliceral base is short and the blade pointed. In most species teeth of the cheliceral blade are restricted to the "tricuspid cap," which consist of a dorsal tooth, a ventral tooth, and the point of the blade. In species of *Hannemania* the cheliceral blades are expanded distally and provided with additional teeth. Species of *Chelandonta* have a ventral row of minute serrations on the cheliceral blade. Only species of *Acomatacarus* and *Whartonia* have teeth on the dorsal margin of the blade, as do most nymphs.

Palpi of larvae are of rather similar shape. There is no distinct trochanter. The setal arrangement is mostly constant. There is one dorsal seta on the femur, and one dorsal seta on the genu; the tibia has one dorsal, one lateral, and one ventral seta. The condition of these palpal setae (whether nude or with branches) is a specific character. There are no accessory claws; the major claw is present and is presumably always branched, thus differing from that of the nymph. The number and arrangement of these branches is a specific character and to some extent a group character. The vestiture of the palpal tarsus is variable but has been little studied.

Other features of the gnathosoma have been little used. The galeal setae are seemingly homologous to the apical hypostomal setae of the nymph. The galeae are paired processes which appear to curve dorsally around the chelicerae. Each bears a seta; the characteristics of these setae are used as specific characters.

The scutal plate contains the characters most used in larval classification. Basically this is a rectangular plate bearing several setae. One anteromedian seta is present in most species (paired in Leeuwenhoekiinae, absent in *Walchia*). The four corners each bear a seta in most species, but in *Pseudoschöngastia* the posterolateral setae are off the scutum and *Walchia* bears additional posterior setae. Scutal shapes are correspondingly modified; the scutum is shortened in *Pseudoschöngastia* and lengthened in *Walchia.* The shape of the scutum has been used as a specific character and sometimes as a group character. Most species of *Euschöngastia* have broad short scuta. Species of *Trombicula* have scuta which vary from rectangular to pentagonal, with the apex directed posteriorly. In *Neoschöngastia* the scutum is partially submerged beneath the cuticular striae. Leeuwenhoekiine genera (except *Whartonia*) have a small anteromedian projection on the anterior margin. The sensilla vary from flagelliform to expanded. The nature and degree of branching is used as a specific character among those species with flagelliform sensilla. When expanded, the degree of expansion is used as a specific character; these sensilla are all more markedly enlarged than any of the sensilla of the postlarval stages. Expanded sensilla are characteristic of the genera *Cheladonta, Euschöngastia, Euschöngastoides* (one of two species), *Neoschöngastia,* and *Pseudoschöngastia.* Scutal markings associated with the sensillary bases are used as specific characters. A series of ten "standard" measurements taken on the scutum are used as specific characters. Scutal modifications in the larval stages do not seem to be related to modifications in the nymphal stage.

Shapes and details of branching of body setae have been used as specific and sometimes generic characters; usually these setae are not so strongly modified as are those of the nymphs, and the characters have not been extensively used. The body setae of the larvae are arranged in rows and can be easily counted; their number and arrangement are specific characters.

Some group and specific characters are taken from the legs. Legs contain six or seven segments, depending on the division of or fusion

of the femur. In the leeuwenhoekiines all legs have six segments. Trombiculine species have seven segments in leg I and usually seven in legs II and III; *Walchia* and *Pseudoschöngastia* clearly have six segments in legs II and III, and it is difficult to determine whether the femoral division is complete in some other species. The setation of the legs is sparse and constant, so the number and nature of leg setae is a widely used specific character.

Characters which retain similar states in both larval and postlarval stages would be of considerable interest, since it would be possible to predict the characters of one stage from those of the other. However, such characters are very few. Sasa (1953:429) mentions three features which are similar in larva and postlarva, these being color, nature of the basal part of the sensillum, and number of anteromedian and tectal setae. The present writer must find fault with the first two of these.

The color shown by trombiculids is undoubtedly influenced by environment and by age, as may be seen in cultures. Although some species show little color variation (for example, species of *Pseudoschöngastia* and *Walchia*) others show a wide range. Larvae of *Trombicula montanensis* range in color from white to dark orange; nymphs range from yellow to orange. The writer has placed larvae in culture which he characterized as "yellow"; nymphs produced from these larvae were characterized as "orange." On the other hand, Loomis (personal communication) has collected and cultured adults of *Trombicula splendens* (normally red) which were white; larvae obtained from these adults were also white. Thus, while the color of larval and postlarval stages is related and may be similar, variation is great enough that the writer would hesitate to predict the color of one stage from that of the other.

Since a character that has been emphasized in studies of the larval stage is the sensilla (whether flagelliform or expanded) any similar or related modifications of the sensilla of the postlarval stages would be of greatest interest. Unfortunately no such related modifications were found; it is not possible to tell from the sensilla of the nymph whether the larva had flagelliform or expanded sensilla. Sasa observed that some species of *Leptotrombidium* have similar short basal branches on the sensilla in both larval and postlarval stages. This must be regarded as an exceptional case; no constant relationship appears among the species studied by the writer.

The number of anteromedian setae on the larval scutum is directly related to the number of tectal setae on the adult scutum, as

reported by Sasa and by others. Leeuwenhoekiine species have two tectal setae and two anteromedian setae; species of *Walchia* have no tectal setae and no anteromedian setae, while other trombiculines have one tectal seta and one anteromedian seta. The nature of the tectal setae (length, modification of stem, and details of branching) are perhaps related in some species but not in most.

Other features occasionally show similarities in larva and postlarva for some species. For example species with large larvae often have large nymphs, but this relationship is far from constant.

Trombiculid mites are certainly not unique in this exhibition of independent variation of characters in two differently adapted stages. Where two stages lead different modes of existence, such independent variation is an obvious advantage, since characters selected for in one stage need not be exposed to adverse selection in subsequent stages. Seemingly natural selection has built up a group of genes which do not express themselves (or have little expression) in the larval stage but which have their major effects in the postlarval stages. The metamorphosis of holometabolous insects is a similar and better-known phenomenon.

When considering these problems it is necessary to bear in mind constantly that the larva, nymph, and adult of an individual are all the same animal; that there is but one genotype for the individual; and that the effects of selection on the characters of any one stage will be felt upon the entire genotype.

TAXONOMY OF THE NYMPHAL STAGE

Nearly all of the species and group names used in this study are based upon the larval stage. Only about half of the established genera are known as postlarvae, and but a small fraction of the described species are known as postlarvae. These circumstances make difficult the construction of group diagnoses and keys; one is hesitant to characterize a genus on a few species when he is aware of the existence of many more species, and perhaps he has not even seen the type of the genus, which he certainly should consider. Womersley (1952) has provided keys to genera and species but usually omits a formal diagnosis for groups, Sasa's (1952) excellent work lacks even keys, and Wharton and Fuller (1952) include only the postlarval characterizations of some groups. The present writer has chosen to use the species at hand as the basis for a full description for each genus, including most characters common to all included species. These descriptions will undoubtedly require modification as more postlarvae are described, but

they may provisionally serve the purpose of a source for critical comparison. In the construction of these descriptions the previously described species were considered; however, as most forms are inadequately known, it was not possible to tell how accurately these fit the generic descriptions. In certain cases previously described species do not agree with the generic characters. These species are provisionally placed in genera but the generic diagnoses will obviously have to be modified when these species are better known and can be classified with greater certainty.

The keys include most of those genera known as postlarvae, but some are inadequately described and were not placed in the keys. These keys were designed primarily for nymphs but will probably classify most adults as well. Keys to species are given; however, in most cases it was possible only to include those species seen by the writer. These specific keys will have little value except in the midwestern region of the United States, but it is hoped that they can be of use also in the study of other postlarvae when they are known.

In the generic diagnoses, characters are numbered and are presented in the same sequence for each genus; the numbers facilitate comparisons and discussions. Within each subfamily each character retains its number for all generic descriptions, but the systems are different for the two subfamilies. Particularly important characters in generic recognition are italicized.

In descriptions, the synonomy of each species is not complete, but includes only the original citation, some different name combinations, and important references to larva or postlarva. Complete synonymies for most included species may be found in Wharton and Fuller (1952) augmented by Loomis (1956).

Group characters are not repeated in the specific descriptions. Measurements are given in microns, except where indicated; means followed by their standard errors are used where possible. Setal counts on the palpal tibia and tarsus include only branched setae; the nude seta at the base of the palpal claw, the tarsala, and the apical nude setae of the tarsus are not included in these counts.

In the listing of specimens examined, a uniform procedure was followed similar to that of Loomis (1956). First is given the total number of nymphs examined by the writer. Then follows the collection data pertaining to the larval hosts of these nymphs, in the following order: State, county, exact locality (where known), host, and the date host was taken. The collector of the host is omitted in most cases; usually these animals were taken by the University

of Kansas Chigger Project and were either obtained by Richard B. Loomis or catalogued by him. Lastly, for each collection the number of nymphs examined is given, with an indication of the persons who reared them. Workers on the Project are identified by initials, as follows: DAC: D. A. Crossley, Jr.; EHK: Ervin H. Kardos, LJL: Louis J. Lipovsky; RBL: Richard B. Loomis. Also, where nymphs were identified by recovering their larval skins, this is indicated in parentheses. Otherwise, nymphs were identified by association of larvae or by comparison with other nymphs.

FAMILY TROMBICULIDAE Ewing

Ewing, 1944, Proc. Biol. Soc. Washington, vol. 57, p. 101.

Diagnosis (nymph).—Body small to medium in size (about 0.4-1.2 mm.); white to red in color; constricted or not; oval to somewhat elongated; provided with numerous branched or modified setae. Eyes sometimes present, 1/1 or 2/2, anterior to or adjacent to sensillary area. A rectangular to pentagonal closed sternum usually present between anterior coxae; sternum sometimes open behind, precoxal plates of coxae I sometimes present; sternal area sclerotized or not. Genital opening between coxae IV; genital plates bearing six genital setae in addition to body setae; only two pairs of genital suckers. Anus posterior to genital opening, divided or not. Legs in two groups; each leg of seven segments and bearing a pair of claws; both branched and nude setae numerous on legs, particularly legs I; tarsus I with or without apical stumplike process.

Gnathosoma with basis capituli evident as a sclerotized ring, bearing hypostome, palpi, and chelicerae. Pharynx usually indistinct but rarely visible due to reticulate markings. Hypostome usually pointed, projecting; occasionally blunt; bearing about eight usually nude, apical setae or about twenty nude or nearly nude apical setae. Chelicerae composed of base, blade, and inconspicuous pseudochela; base stout to elongated; blade usually shearlike, sometimes daggerlike or strongly curved, usually with dorsal teeth or serrations. Palpi composed of five segments: trochanter small, without setae; femur large, with branched setae; genu large but smaller than femur, with branched setae; tibia small, somewhat pointed, bearing claw at apex and usually two subapical accessory claws, several branched setae, and a nude seta on lateral surface at base of claw; tarsus small, articulated to ventral surface of tibia, bearing several usually branched setae, one tarsala, and one to several short apical nude setae.

Scutum composed of anterior membranous tectum, rodlike crista, and posterior sensillary area. Tectum large to small; usually hyaline but sometimes slightly sclerotized; margin smooth or bearing teeth or serrations; with one, two, or no tectal setae. Crista usually a thin rod, sometimes very thin or broadened; sometimes with prominent punctation. Sensillary area variable in shape, from circular to transverse-oval or triangular; variously modified; bearing two sensilla, these flagelliform to subclavate and usually with branches; area usually surrounded by ridges; usually with a posterior apodeme.

Remarks.—The combination of bladelike chelicerae (never elongate-stylettiform), no more than two tectal setae, and a single pair of sensilla on the scutum, will separate trombiculid nymphs and adults from most of the genera in the trombidioid complex. The constricted, "figure 8-shaped" body is not characteristic of all genera but is nevertheless a useful field character.

Extensive larval diagnoses have been given by Wharton and Fuller (1952:40) and by Loomis (1956:1229).

Family rank is accorded these mites by most workers, although some prefer a subfamily rank in the family Trombidiidae. Womersley recognizes two families, Trombiculidae and Leeuwenhoekiidae. The proper position must, of course, be decided by comparison of the chiggers with their closest relatives, which are obviously the trombidiids. Such a comparison has been quite difficult, since trombidiids are mainly known from their adult stage, while trombiculids are mainly known as the larval chiggers. More recent studies of reared material have increased knowledge of both groups and the result is an increasing difficulty in separating them. The trombidiid genus *Neotrombidium,* for example, is morphologically more similar to leeuwenhoekiine genera than to most trombidiid genera. The biological character of vertebrate parasitism by trombiculids and invertebrate parasitism by trombidiids will exclude these questionable genera from Trombiculidae; they may be excluded on morphological grounds by a rigid and perhaps artificial definition such as that given above. However, these techniques do not solve the problems of the limits of the trombiculid group or place them in their proper taxonomic position.

At the present time the best solution appears to be retention of the family rank for trombiculids, until such time as the accumulated evidence either verifies the position or forces a change to subfamily (or superfamily) status. Knowledge of trombidiids is still fragmentary; trombiculids are better known but still require

extensive taxonomic investigation at the higher levels. The evidence for change at the present must be judged inconclusive.

Subfamilies.—Most workers divide the Trombiculidae into four subfamilies, these being Trombiculinae, Walchiinae (= Gahrliepiinae), Leeuwenhoekiinae, and Apoloniinae. The two latter subfamilies Womersley places in Leeuwenhoekiidae. As no species of Apoloniinae are known as postlarvae, this subfamily must be omitted from the following discussions.

The subfamily Walchiinae has recently become a trouble-spot in chigger taxonomy. Wharton and Fuller (1952:41) separate Walchiinae from Trombiculinae in the larval stage by the number of segments in legs II and III; Walchiinae have but six segments, the femurs being undivided, while trombiculines have seven segments due to the division of the femora into basifemur and telofemur. Some workers, including the writer, have experienced difficulty in using this character. Womersley (1952:278) resolved the problem by removing to Trombiculinae the genera *Pseudoschöngastia* and *Walchiella,* and considering the remaining genera congeneric with *Gahrliepia* (with the subfamily name Gahrliepiinae). Larvae were diagnosed by the absence of the anteromedian scutal seta (present in Trombiculinae) and postlarvae were recognized by the presence of an apical stumplike process on tarsus I (absent in Trombiculinae). Audy (1954:161) and Loomis (1956:1362) followed Womersley's arrangement but expressed doubts as to the propriety of recognizing only the genus *Gahrliepia.*

The writer's studies of postlarval stages show that *Walchia* is closely similar to both *Pseudoschöngastia* and *Euschöngastoides;* it appears that a subfamily would have to contain all three of these genera. However, such a subfamily would be difficult to diagnose on the characters based on the larval stage, since the included species would combine such features as anteromedian scutal seta present or absent, scutum reduced (*Pseudoschöngastia*) or extended (*Walchia*), sensilla globose or flagelliform (*E. hoplai*), and legs II and III six- or seven-segmented. Also, larvae of species of *Euschöngastoides* and perhaps *Pseudoschöngastia* are very similar to some undoubted trombiculines. Nevertheless, the impression remains that these three genera form a natural group. It may be that further studies on the larval stage will produce characters which justify the recognition of a subfamily in spite of the diversity in that stage. Until this is accomplished the subfamily Walchiinae (or Gahrliepiinae) must be abandoned as a synonym of Trombiculinae.

KEY TO SUBFAMILIES OF TROMBICULIDAE (NYMPHS)

1. Tectum with two setae, usually side-by-side; sensilla long, flagelliform, without branches; setae on palpal genu less numerous than those on palpal femur ..... *Leeuwenhoekiinae* p. 192
1'. Tectum with one seta or without setae; sensilla variable, with at least short basal branches (except *Blankaartia*); setae on palpal genu more numerous than those on palpal femur, or the same number on those segments ..... *Trombiculinae* p. 205

Subfamily Leeuwenhoekiinae Womersley

Womersley, 1944, Trans. Roy. Soc. South Australia, vol. 68, p. 102.

Diagnosis (*nymphs*).—Body oval, not constricted (except *Hannemania*). Tectum with two setae, usually side-by-side. Sensilla long, flagelliform, without branches. Anus circular, not obviously divided into two shoelike portions. Setae on palpal genu less numerous than those on palpal femur.

Additional features (*nymphs*).—Body with eyes present or absent, 1/1 or 2/2, anterior to and separated from sensillary area; sternal area sclerotized but no true sternum formed by a crossbar connecting coxae II; precoxal plates never present. Gnathosoma with cheliceral base of usual shape (mean ratio BL/BH: 1.8-2.4), cheliceral articulation with basis capituli ventral; two accessory claws on palpal tibia; pharynx inconspicuous, not marked with reticulate pattern. Scutum with tectal margin smooth; mean ratio ASL/SB: 3.2-5.1; bulla absent; lateral keels absent; carina absent; basal plate of two straplike bands; only posterior and lateral ridges on sensillary area; apodeme present.

Included genera.—Known from both larvae and postlarvae: *Acomatacarus* Ewing, *Chatia* Brennan, *Hannemania* Oudemans, *Leeuwenhoekia* Oudemans, and *Whartonia* Ewing. Known from larvae only: *Odontacarus* Ewing and *Shunsennia* Jameson and Toshioka.

Remarks.—The included genera are substantially separable from the trombiculine genera, so that the subfamily status is merited. As previously mentioned, Womersley (1945:47) has given the group full family rank, but was not followed by Wharton and Fuller (1952:96). The present writer also prefers to retain the subfamily rank.

The genus *Odontacarus* (known only as larva) contains but two species. According to Wharton and Fuller (1952:103), "the specimens in existence are too badly damaged to study satisfactorily." "Probably a synonym of *Acomatacarus* (*Acomatacarus*)."

Nymphs of *Shunsennia* have been reared and are being described by Lipovsky (personal communication). All other genera are known as postlarvae, but three of five subgenera of *Acomatacarus* are known as larvae only.

Leeuwenhoekiine larvae are found on amphibians, reptiles, birds, and mammals. The postlarvae are apparently adapted to various habitats.

KEY TO GENERA OF LEEUWENHOEKIINAE (NYMPHS)

1. Body constricted; posterior body setae elongated, each ending in a hooklike spine ..... *Hannemania* p. 200
1'. Body not constricted; posterior body setae not ending in hooklike spines 2
2. Posterior body setae with simple branches; setal tips single, long, attenuated ..... *Chatia* p. 198
2'. Posterior body setae modified, not ending in single, long attenuated tips 3
3. Posterior body setae leaflike ..... *Whartonia* p. 203
3'. Posterior body setae somewhat expanded 4
4. Tarsus longer (mean ratio TL/TH: 6.2), cylindrical in shape *Leeuwenhoekia* p. 193
4'. Tarsus shorter (mean ratio TL/TH: 2.1), rather pyriform in shape *Acomatacarus* p. 195

Genus *Leeuwenhoekia* Oudemans

Leeuwenhoekia Oudemans, 1911, Ent. Berichten, vol. 3, p. 137 (type *Heterothrombium verduni* Oudemans).

Diagnosis (*nymph*).—(1) Body shape, oval, not constricted. (2) *Posterior body setae modified, expanded.* (3). *Ratio TL/TH about 6.2.* (4) *Tarsus I cylindrical.*

Additional features (*nymph*).—(5) Body size medium (about 0.8 mm. long). (6) Eyes 1/1. (7) Adjacent body setae of similar lengths. (8) Sclerotized sternal plate present. (9) *Legs not unusually elongated; branched setae slightly expanded.* (10) Cheliceral blade shearlike. (11) Palpus moderate in size; claw moderate in size; tarsus with about nine branched setae and six or seven apical nude setae. (12) Hypostome pointed, projecting, with about eight apical nude setae and about twenty ventral branched setae. (13) Basis capituli of normal shape. (14) Tectum large, well sclerotized, saggitate in shape; tectal setae elongated, not expanded. (15) Crista a narrow rod. (16) Sensillary area oval; mean ratio ASL/SB: 5.1. (17) About ten to fifteen parascutal setae.

Remarks.—Wharton and Fuller (1952:96) recognize but two species of *Leeuwenhoekia* in two subgenera; these are *verduni*

(Oudemans) in the typical subgenus and *americana* (Ewing) in the subgenus *comatacarus* Ewing. Since *verduni* has not been reared, the above description is based upon *americana* only.

Leeuwenhoekia as represented by *americana* is very similar to *Acomatacarus* (*Acomatacarus*); these two may be separated by the shape of tarsus I as evidenced by characters (3) and (4) but these are of doubtful generic significance (some postlarvae of *Acomatacarus,* as described by Womersley, probably key to *Leeuwenhoekia*). If *americana* is really congeneric with *verduni,* the *Acomatacarus* is probably a synonym of *Leeuwenhoekia.*

Leeuwenhoekia americana (Ewing)

(Figs. 18, 62, 96, 97, 140, 185, 197)

Comatacarus americanus Ewing, 1942, Jour. Parasit., vol. 28, p. 490 (*larva*).
Leeuwenhoekia (*Comatacarus*) *americanus,* Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 96 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1234-1235 (*larva*).

Description of nymph.—Body: About 0.8 mm. long, color yellow. Eyes red in life, about 12 μ in diameter. Setae expanded; tips rounded; branches thick; posterior setae about 20 μ long. Sternal area containing nearly square sclerotized plate bearing 8 setae. Measurements of tarsus I (1 specimen); TL: 185, TH: 30, TL/TH: 6.2.

Gnathosoma: Cheliceral base stout, with conspicuous puncta; blade with about 15 flat teeth. Cheliceral measurements (1 specimen); BL: 109, BH: 58, CL: 66, BL/BH: 1.9, BL/CL: 1.7. Palpus with outer femoral and outer genual setae bearing short paired branches rather than longer single branches; tarsus with 4 inner, 2 outer apical nude setae; tarsala about 13 μ long. Setal counts (1 specimen); femur: 15.5, genu: 10, tibia: 6, tarsus: 9.

Scutum: Tectal setae apical. Crista with several puncta. Basal plate broad; apodeme narrow and elongated; sensillary bases towards posterior of sensillary area. Scutal measurements (1 specimen); ASL: 107, SB: 21, TS: 43, SENS: about 60, ASL/SB: 5.1.

Remarks.—On the single occasion on which this species was reared, one of two larvae reached the nymphal stage. (The nymph was offered collembola eggs but did not eat.

Specimens examined.—One nymph, as follows: KANSAS. *Cheyenne County:* 15 mi. N, 11½ W St. Francis, *Peromyscus maniculatus,* November 1, 1952 (1 nymph, reared DAC).

Genus *Acomatacarus* Ewing

Acomatacarus Ewing, 1942, Jour. Parasit., vol. 28, p. 490 (type *Acomatacarus arizonensis* Ewing).

Diagnosis (*nymph*).—(1) Body shape oval, not constricted. (2) *Posterior body setae modified, expanded.* (3) Mean ratio TL/TH: about 2.1. (4) *Tarsus I rather pyriform.*

Additional features (*numph*).—(5) Body size small to medium (about 0.4-0.6 mm. long). (6) Eyes absent or 1/1. (7) With or without long and short body setae intermixed. (8) Sclerotized sternal plate present. (9) *Legs not unusually elongated; branched setae slightly expanded.* (10) Cheliceral blade shearlike or daggerlike. (11) Palpus short, rather small; *some femoral setae expanded, some genual setae expanded;* claw moderate in size; tarsus with about six to eight branched setae and three to five apical nude setae. (12) Hypostome pointed and projecting, or blunt; six to eight apical setae, nude or branched; about ten ventral branched setae. (13) Basis capituli normal to broad and short in shape. (14) Tectum well sclerotized, intermediate in size; tectal setae expanded or not. (15) Crista rodlike, narrow or somewhat broadened. (16) Sensillary area oval to transverse-oval; mean ratio ASL/SB: 3.2-4.5. (17) About ten to fifteen parascutal setae.

Remarks.—Womersley (1945:98) described the reared nymphs of *Acomatacarus australensis* (Hirst), *A. longipes* (Womersley), and *A. nova-quinea* (Womersley). He also placed in that genus *Rhyncholophus retentus* Banks, *Dromeothrombium dromus* Womersley, and *Acomatacarus patrius* Womersley, all known only as adults. Their affinities with *Acomatacarus* were established by comparisons with the reared nymphs mentioned above. This action appears to have been well taken. The diversity of forms suggests that eventually some generic reassignments will prove necessary but for the present a broad genus *Acomatacarus* seems advisable.

The descriptions of these species as given by Womersley are generally in agreement with the generic description proposed by the writer. One species, *dromus,* has long unmodified body setae. Womersley reports that all of the species have no accessory palpal claws but instead three or four short spines at the base of the main claw. This observation should be verified.

In addition to the above mentioned species and the two described in this paper, some 35 species of *Acomatacarus* known only from the larval stage have been described.

KEY TO SUBGENERA OF ACOMATACARUS (NYMPHS)

1. Cheliceral blade shearlike . . . . . *A.* (*Acomatacarus*) p. 196
1'. Cheliceral blade narrow, daggerlike . . . . . *A.* (*Xenacarus*) p. 197

Subgenus *Acomatacarus* Ewing

Acomatacarus, Womersley, 1945, Trans. Roy. Soc. South Australia, vol. 69, p. 98 (*nymph*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 97 (*nymph*).

Diagnosis (*nymph*).—(10) *Chelicera with blade shearlike.* (11) Palpal tarsus with five apical nude setae. (12) *Hypostome pointed, projecting,* with about eight apical nude setae. (14) Tectal setae not expanded.

Remarks.—These features appear to be the ones of subgeneric importance which characterize *A.* (*Acomatacarus*) as opposed to *A.* (*Xenacarus*). The postlarvae described by Womersley appear to fall within the typical subgenus.

Acomatacarus arizonensis Ewing

(Figs. 37, 142, 209)

Acomatacarus arizonensis Ewing, 1942, Jour. Parasit., vol. 28, pp. 490-491 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1236-1238 (*larva*).

Description of nymph.—Body: about 0.4 mm. long, color dull red. Eyes absent. Setae expanded; tips rounded; branches thin and short; most setae short but longer ones (2-3 times longer) scattered among these; posterior setae (longer ones) about 30 μ long. Sternal area with broad plate bearing ten modified setae. Measurements of tarsus I (1 specimen); TH: 36, TL: 75, TL/TH: 2.1.

Gnathosoma: Cheliceral base stout, rather rounded, punctate; blade with about 16 small teeth; apodeme of blade not constricted, and blunt. Cheliceral measurements (1 specimen); BL: 56, BH: 31, CL: 36, BL/BH: 1.8, BL/CL: 1.6. Palpus somewhat stout; outer femoral and outer genual setae slightly expanded; tarsus with 3 inner, 2 outer apical nude setae; tarsala not seen. Setal counts (1 specimen); femur: 9-10, genu: 5-6, tibia: 5, tarsus: 8.

Scutum: Tectal setae apical. Crista rather broad. Sensillary area with apodeme broad; sensillary bases small; basal plate wide. Scutal measurements (1 specimen); ASL: 58, SB: 18, TS: 20, SENS: about 60, ASL/SB: 3.2.

Remarks.—Several additional attempts to rear this species were unsuccessful, possibly due to inadequate moisture control. The species appears to be restricted to arid situations (see Loomis, 1956:1237).

A. arizonensis lacks striking distinctive features; most of the known postlarvae of *Acomatacarus* are clearly congeneric with *arizonensis* (the genotype), on the basis of their descriptions.

In the key given by Womersley (1945:110), *arizonensis* (as nymph) will key out to *dromus* (known only as adult). These species may be separated by the form of the body setae; in *arizonensis* the dorsal body setae are expanded while in *dromus* they are slender.

Specimens examined.—One nymph, as follows: *Arizona.* Cochise County: *Sceloporus jarrovii,* July 8, 1951, taken by H. S. Fitch (1 nymph, reared LJL).

Subgenus *Xenacarus* Greenberg

Xenacarus Greenberg, 1951, Jour. Parasit., vol. 37, p. 525 (type *Acomatacarus* (*Xenacarus*) *plumosus* Greenberg).

Diagnosis (nymph).—(10) *Chelicera with blade straight, daggerlike.* (11) Palpal tarsus with three apical nude setae. (12) *Hypostome blunt,* with about six to eight apical, sparsely-branched setae. (14) Tectal setae somewhat expanded.

Remarks.—Of these features, the blunt hypostome and the straight, daggerlike cheliceral blade appear to be characters of group importance. The expanded tectal setae are of interest. Other species with expanded or modified body setae nevertheless have slender tectal setae.

Acomatacarus plumosus Greenberg

(Figs. 34, 88, 134, 135, 138, 189, 205, 207)

Acomatacarus plumosus Greenberg, 1951, Jour. Parasit., vol. 37, pp. 525-527 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1240-1241 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color white. Eyes 1/1; red in life; about 12 μ in diameter. Setae with body expanded but base of normal size; tips rounded; branches of two types, mostly large and heavy but with small branches interspersed; adjacent setae of similar lengths; posterior setae about 25 μ long. Sternal area with very broad plate bearing about ten modified setae. Measurements of tarsus I (means of 9 specimens); TL: 124.7 ± 2.789; TH: 58.2 ± 1.025, TL TH: 2.13 ± 0.0289.

Gnathosoma: Chelicera with base rather stout, punctuate; blade with about 12 small flat teeth; apodeme of blade not constricted. Measurements of chelicerae (means of 9 specimens); BL: 60.7 ± 0.928, BH: 32.9 ± 0.605, CL: 37.9 ± 0.754, BL/BH: 1.84 ± 0.041,

BL/CL: 1.61 ± 0.0602. Palpus somewhat stout; outer femoral and outer genual setae expanded; tarsus with 2 inner, one outer apical nude setae; tarsala 8 μ long. Setal counts; femur: 10.56 ± 0.448 (8 specimens), genu: 6.8 ± 0.214 (10 specimens), tibia: range 4-5, tarsus: range 6-7.

Scutum: Tectal setae apical; expanded, resembling body setae. Crista narrow. Sensillary area oval; basal plate narrow; apodeme narrow. Scutal measurements (means of 8 specimens); ASL: 104.8 ± 3.98, SB: 23.7 ± 0.799, TS: 26.3 ± 2.496, SENS: about 100, ASL/SB: 4.53 ± 0.1878.

Remarks.—This species was reared to the nymphal stage on several occasions. Collembola eggs were offered as a food material and the nymphs possibly ate the eggs or the freshly-hatched collembolans; feeding was not observed. It is not certain that they fed at all.

A. plumosus is readily identified by the form of the body setae. In other respects it also differs markedly from *arizonensis*, and is probably generically distinct. The one other species of *Acomatacarus* (*Xenacarus*), *A. brevicalar* Brennan and Jones, is known as larva only.

Specimens examined.—Total 16 nymphs, as follows: KANSAS. *Barber County:* 4 mi. S Aetna, *Neotoma micropus*, August 22, 1949 (4 nymphs, reared LJL), September 15, 1953 (3 nymphs, reared DAC, idet. by larval skin); 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (8 nymphs, reared LJL); 4 mi. S Aetna, *Peromyscus leucopus*, September 15, 1953 (1 nymph, reared DAC).

Genus *Chatia* Brennan

Chatia Brennan, 1946, Jour. Parasit., vol. 32, p. 132 (type *Chatia setosa* Brennan); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 163 (*nymph*).

Diagnosis (*nymph*).—(1) Body shape oval, not constricted. (2) Posterior body setae not modified, branched, and *ending in long, single, attenuated tips;* not expanded. (3) Ratio TL/TH: 2.5. (4) Tarsus I cylindrical.

Additional features (*nymph*).—(5) Body size medium (about 0.8 mm. long). (6) Eyes 1/1. (7) Adjacent body setae of similar lengths. (8) Sclerotized sternal plate present. (9) Legs unusually elongated; branched setae not expanded. (10) Cheliceral blade shearlike. (11) Palpus stout, large; claw somewhat elongated; tarsus with about fourteen branched setae and six or seven apical nude setae. (12) Hypostome pointed, projecting; with about eight

apical nude setae and numerous ventral branched setae. (13) Basis capituli of normal shape. (14) Tectum well-sclerotized, large, saggitate in shape; setae elongated, not expanded. (15) *Crista a broad rod, with prominent punctation.* (16) Sensillary area oval; ratio ASL/SB: 5.1. (17) About ten to fifteen parascutal setae.

Remarks.—A few characters for nymphs of *Chatia* were given by Wharton *et al.* (1951:30) and by Audy (1954:163). Most noteworthy are the elongated legs (all longer than the body), the prominent puncta of the crista, and the attenuated tips of the body setae.

Chatia setosa Brennan

(Figs. 16, 92, 93, 141, 190, 210)

Chatia setosa Brennan, 1946, Jour. Parasit., vol. 32, p. 132 (*larva*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 163 (*nymph*).

Description of nymph.—Body: About 0.8 mm. long, color not known. Eyes about 23 μ in diameter. Body setae normal, with rather short branches; tips long, single, attenuated; posterior setae about 75 μ long. Sternal area containing nearly square sclerotized plate, bearing about 30 setae. Legs noticeably elongated, all longer than body. Measurements of tarsus I (means of 3 specimens); TL: 266.3 ± 17.37, TH: 107.0 ± 2.517, TL/TH: 2.50 ± 0.2082.

Gnathosoma: Chelicera with base large, stout, punctate; blade with about 35 to 50 small to tiny teeth, apodeme of blade not constricted. Cheliceral measurements (means of 3 specimens); BL: 175.7 ± 1.33, BH: 75.0 ± 1.15, CL: 99.0 ± 1.00, BL/BH: 2.33 ± 0.067, BL/CL: 1.80 ± 0.0000. Palpus with setae numerous; tarsala about 13 μ long; tarsus with apical nude setae arranged 1 outer, 5 or 6 inner. Setal counts (means of 3 specimens); femur: 30.43 ± 1.00, genu: 20.00 ± 1.50, tibia: range 8-11, tarsus: range 13-18.

Scutum: Crista broadly joined to sensillary area; apodeme large, prominent; sensillary bases at back of sensillary area. Scutal measurements (means of 3 specimens); ASL: 159.7 ± 5.84, SB: 32.5 ± 0.500, TS: 85.7 ± 4.63, SENS: about 120, ASL/SB: 5.10 ± 0.100.

Remarks.—This is the only species in the genus. The specimens were reared by Dr. James M. Brennan, and were originally loaned to Mr. Louis J. Lipovsky. Dr. Brennan and Mr. Lipovsky have very kindly allowed me to describe them.

Specimens examined.—Total 3 nymphs, as follows: Montana. *Ravalli County: Citellus lateralis cinerascens,* field no. AP-22355, May 22, 1946 (2 nymphs, reared by Dr. Brennan); *Tamiasciurus*

hudsonicus richardsoni, field no. AP-21201, November 11, 1944 (1 nymph, reared by Dr. Brennan).

Genus *Hannemania* Oudemans

Hannemania Oudemans, 1911 Ent. Berichten, vol. 3, p. 137 (Type *Heterothrombium hylodeus* Oudemans); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*adult*).

Diagnosis (*nymph*).—(1) *Body constricted, figure 8-shaped.* (2) Posterior body setae elongated, not expanded, *each ending in hooklike spine.* (3) Mean ratio TL/TH: 2.1-2.5. (4) Tarsus I nearly cylindrical.

Additional features (*nymph*).—(5) Body size medium to large (about 0.9-1.2 mm.). (6) *Eyes 2/2.* (7) Adjacent body setae of similar lengths. (8) Sternal area sclerotized. (9) Legs not unusually elongated; branched setae not expanded. (10) Cheliceral blade shearlike. (11) Palpus stout, size moderate to large; claw moderate in size; tarsus with about ten to twenty branched setae and five apical nude setae. (12) Hypostome pointed, projecting; with about eight apical nude setae and numerous ventral branched setae. (13) Basis capituli normal to short and broad in shape. (14) *Tectum small*, well-sclerotized; tectal setae elongated, not expanded. (15) Crista a narrow rod. (16) Sensillary area oval; mean ratio ASL/SB: 3.7-4.5. (17) *About fifty parascutal setae.*

Remarks.—Larvae of species of *Hannemania* parasitize only amphibians; they are unique in that they burrow into the skin. The larvae may also be recognized by their peculiar, expanded chelicerae.

Postlarvae are distinct from other leeuwenhoekiines particularly in characters (1), (2), (6), (14), and (17) as indicated above. Of these, the constricted body (1) is puzzling since this feature is typical of Trombiculinae. Otherwise, *Hannemania* is more closely similar to other leeuwenhoekiines. Mounted specimens are readily identified by the strong hooklike tips of the posterior body setae.

The genus is widespread in the New World, but has not been recently revised. Of the some fifteen described species, only one was previously known in postlarval stages. Nymphs and adults of *Hannemania hylae* (Ewing) were described by Ewing (1926:266, figs. 3-4). His descriptions and figures are similar to the species described here, in general, but he did not give enough details for specific recognition.

KEY TO SPECIES OF HANNEMANIA (NYMPHS)

1. Cheliceral blade rather broad (fig. 19) ..... *multifemorala* p. 203
1'. Cheliceral blade narrow (fig. 20) 2
2. Generally smaller; mean ASL about 150 μ, range 117-170 μ; mean SB about 34 μ, range 21-38 μ; distance across both eyes about 40 μ ..... *eltoni* p. 202
2'. Generally larger; mean ASL about 218 μ, range 215-220 μ; mean SB about 53 μ, range 49-56 μ; distance across both eyes about 80 μ ..... *dunni* p. 201

Hannemania dunni Sambon

(Fig. 204)

Hannemania dunni Sambon, 1928, Ann. Trop. Med. Parasit., vol. 22, p. 129 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1246 (*larva*).

Description of nymph.—Body: About 1.2 mm. long, color red. Eyes red in life, distance across both eyes about 80 μ. Setae thick but not expanded, branches as usual; tip of each a recurved hook-like spine; posterior setae about 70 μ long. Sternal area about square, sclerotized, with about 15 setae. Measurements of tarsus I (1 specimen); TL: 270, TH: 110, TL/TH: 2.5.

Gnathosoma: Basis capituli of normal shape. Cheliceral base of usual shape, with numerous conspicuous puncta; blade shearlike but narrowed, with about 23 small teeth, apodeme of blade not constricted. Cheliceral measurements (means of 3 specimens); BL: 187.3 ± 4.06, BH: 78.0 ± 3.61, CL: 105.7 ± 2.73, BL/BH: 2.37 ± 0.058, BL/CL: 1.77 ± 0.033. Palpus of usual shape; tarsala about 18 μ long; tibia without seta at inner tarsal articulation, but with stiff monopectinate seta below accessory claws; tarsus with 4 inner, 1 outer apical nude setae. Setal counts (1 specimen); femur: 45, genu: 31, tibia: range 7-9, tarsus : range 18-19.

Scutum: Tectal setae apical, set in pits. Apodeme large. Scattered puncta present. Scutal measurements (means of 2 specimens); ASL: 217.5 ± 2.50, SB: 52.5 ± 3.501, TS: 56.0 ± 0.000, ASL/SB: 4.15 ± 0.2500.

Remarks.—This species, like *H. eltoni*, proved easy to culture and as a result more adults were available for study than nymphs. Both nymphs and adults ate collembola eggs.

Hannemania dunni is very similar to *H. eltoni*. The characters used to separate these two as nymphs involve size, *dunni* being much the larger.

Loomis (1956:1246) identifies larvae from which these nymphs

were reared, as *Hannemania dunni* and I accept his identification. However, these larvae are somewhat larger than other *dunni* of Loomis and may be specifically distinct.

Specimens examined.—Total 4 nymphs, as follows: ARKANSAS. *Montgomery County: Plethodon caddoensis,* January 26, 1952, taken by H. A. Dundee (4 nymphs, reared DAC).

Hannemania eltoni Sambon

(Figs. 20, 61, 98, 99, 139)

Hannemania eltoni Sambon, 1928, Ann. Trop. Med. Parasit., vol. 22, p. 129 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1243 (*larva*).

Description of nymph.—Resembles *Hannemania dunni,* except as follows:

Body: About 0.9 mm. long. Distance across both eyes about 40 μ. Setae with branches longer; posterior setae about 45 μ long. Measurements of tarsus I (means of 9 specimens); TL: 184.5 ± 6.01, TH: 86.2 ± 2.72, TL/TH: 2.14 ± 0.0503.

Gnathosoma: Basis capituli short, broad. Cheliceral base not heavily punctate; blade with about 14-29 teeth. Cheliceral measurements (means of 9 specimens); BL: 120.0 ± 5.21, BH: 53.3 ± 2.69, CL: 74.4 ± 3.00, BL/BH: 2.33 ± 0.110, BL/CL: 1.61 ± 0.035. Palpus with tarsala about 16 μ long. Setal counts; femur: 30.56 ± 2.17 (8 specimens), genu: 18.45 ± 0:575 (10 specimens), tibia: range 5-8, tarsus: range 10-16.

Scutum: Measurements (means of 9 specimens); ASL: 149.6± 5.68, SB: 33.6 ± 1.733, TS: 33.5 ± 0.707, SENS: about 100-150, ASL/SB: 4.5 ± 0.247.

Remarks.—This species is readily cultured. Both nymphs and adults eat collembola eggs.

Loomis (1956:1243) discusses the application of the name *eltoni* to larvae from which these nymphs were reared.

Specimens examined.—Total 24 nymphs, as follows: TEXAS. *Bexar County:* Camp Bullis, *Rana pipiens,* April 25, 1954 (8 nymphs, reared RBL). KANSAS. *Seward County:* 12 mi. NE Liberal, *Rana pipiens,* September 9-10, 1948 (11 nymphs, reared LJL). *Cheyenne County:* 4 mi. N St. Francis, *Rana pipiens,* July 22, 1948 (3 nymphs, reared LJL). *Johnson County:* Sunflower, *Acris gryllus,* March 29, 1949 (2 nymphs, reared LJL).

Hannemania multifemorala Loomis

(Figs. 19, 178)

Hannemania multifemorala Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1247 (*larva*).

Description of nymph.—Resembles *Hannemania dunni* except as follows:

Body: About 1.1 mm. long. Eyes present but indistinct. Posterior body setae about 40 μ long. Measurements of tarsus I (1 specimen); TL: 170, TH: 75, TL/TH: 2.3.

Gnathosoma: Cheliceral base not heavily punctate; blade rather broad, upper margin straight, with about 16 small teeth. Cheliceral measurements (means of 2 specimens); BL: 110.5 ± 10.5, BH: 53.3 ± 4.5, CL: 60.5 ± 9.50, BL/BH: 2.05 ± 0.05, BL/CL: 1.85 ± 0.150. Palpus with tarsala about 11 μ long. Setal counts (1 specimen); genu: 25, tarsus: 13 (other segments obscured).

Scutum: Measurements (1 specimen); ASL: 118, SB: 32, ASL/SB: 3.7.

Remarks.—The presence of this species, which occurs with *H. eltoni,* was not detected until the latter part of our work. It does not culture well, and cultures of *Hannemania* from Kansas appear to be pure *eltoni.* Possibly culture conditions favorable to *eltoni* eliminate *multifemorala.*

Specimens examined.—Total 3 nymphs, as follows: TEXAS. *Erath County:* Stephenville State Park, *Microhyla olivacea,* April, 1952, taken by H. S. Fitch (1 nymph, reared DAC). NEBRASKA. *Richardson County:* ½ mi. W Verdon, *Rana pipiens,* August 20, 1948 (2 nymphs, reared LJL).

Genus *Whartonia* Ewing

Whartonia Ewing, 1944, Proc. Biol. Soc. Washington, vol. 57, p. 102 (type *Hannemania nudosetosa* Wharton); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 164 (*nymph*).

Diagnosis (nymph).—(1) Body shape oval, not constricted. (2) *Posterior body setae modified, leaflike.* (3) Ratio TL/TH: 2.4. (4) Tarsus I rather pyriform.

Additional features (nymph).—(5) Body size medium (0.8 mm. long). (6) Eyes absent. (7) Adjacent body setae of similar lengths. (8) Sclerotized sternal plate present. (9) Legs not unusually elongated; *branched setae slightly expanded.* (10) *Chelic-*

eral blade narrowed, nearly shearlike. (11) Palpus stout, moderate in size; *trochanter short, broad; some femoral, some genual setae expanded;* claw moderate in size; tarsus with seven branched setae and five apical nude setae. (12) *Hypostome blunt,* with six to eight apical setae with reduced branching; about ten branched, slightly expanded ventral setae. (13) Basis capituli of normal shape. (14) Tectum large, well-sclerotized, saggitate in shape; *tectal setae forked,* not expanded. (15) Crista a narrow rod. (16) Sensillary area oval; ratio ASL/SB: 3.6. (17) About ten to fifteen parascutal setae.

Remarks.—The above characterization is based upon *Acomatacarus senase* Greenberg, which Loomis (1956:1241) transferred to *Whartonia.* Although this species does fit the generic diagnosis given by Wharton and Fuller (1952:104) for larvae, possibly it is not congeneric with *Whartonia nudosetosa,* the genotype.

Morphologically *Whartonia senase* is quite similar to *Acomatacarus.* Some features appear to be of group importance, including the narrowed cheliceral blade (10), the short palpal trochanter (11), the blunt hypostome (12) and the forked tectal setae (14). The leaflike modification of the posterior body setae is the most obvious character for recognition.

Besides *W. senase,* four species of *Whartonia* have been described and while some have evidently been reared, the nymphal descriptions have not been published.

Whartonia senase (Greenberg)

(Figs. 36, 60, 94, 95, 143, 182, 187, 234)

Acomatacarus senase Greenberg, 1952, Ann. Ent. Soc. America, vol. 45, p. 484 (*larva*).

Whartonia senase, Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1242 (*larva*).

Description of nymph.—Body: About 0.8 mm. long, color not known. Setae modified as leaflike structures; central stem of each evident but bearing two lateral flanges with sclerotized margins and weblike surfaces; margins of flanges irregular; central stem with small branches; posterior setae about 25 μ long. Sternal area containing broad sclerotized plate, with 8 expanded setae. Measurements of tarsus I (1 specimen) TL: 141, TH: 60, TL/TH: 2.4.

Gnathosoma: Cheliceral base stout, punctate, area of articulation with basis capituli slightly shortened; blade rather narrow but curved, about 10 tiny teeth on apical portion, apodeme of blade not constricted. Cheliceral measurements (1 specimen); BL: 60, BH:

34, CL: 38, BL/BH: 1.8, BL/CL: 1.6. Palpus with dorsal femoral and dorsal genual setae slightly expanded; claw slender; tarsala about 8 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (1 specimen): femur: 12, genu: 10.5, tibia: range 4-5, tarsus, 7.

Scutum: Tectum with margin conspicuously sclerotized; setae forked at about half their length. Crista broadened gradually towards posterior. Apodeme short, blunt. Scutal measurements (1 specimen); ASL: 107, SB: 30, TS: 25, SENS: (obscured), ASL/SB: 3.6.

Specimens examined.—Total one, as follows: KANSAS. *Barber County:* 3½ mi. S, 1 mi. W Aetna, *Myotis velifer,* April 10, 1949 (1 nymph, reared LJL).

SUBFAMILY TROMBICULINAE Ewing

Ewing, 1929, Manual of External Parasites, p. 22.

Diagnosis (nymph).—Body constricted, figue 8-shaped. Tectum with one or no setae. Sensilla variable, with at least short basal branches (except *Blankaartia*). Anus obviously divided into two shoelike portions. Setae on palpal genu more numerous than those on palpal femur, or about the same number on these segments.

Additional features (nymph).—Eyes usually absent; when present 1/1 and either anterior to or adjacent to sensillary area. Sternum variable, rarely open behind or with precoxal plates of coxae I; usually closed behind by a crossbar connecting coxae II. Scutum with tectal margin variable; mean ratio ASL/SB: about 1.0-3.2; bulla usually prominent, sometimes small; lateral keels present; carina usually present; ridges often present in sensillary area. Gnathosoma with cheliceral base elongated to unusually elongated (mean ratio BL/BH: 1.9-4.0); articulation of cheliceral base with basis capituli usually ventral but sometimes terminal; posterior tip of cheliceral base elevated or depressed. Palpus usually with two accessary claws, rarely only one or more than two. Pharynx usually inconspicuous but sometimes marked with a reticulate pattern.

Diagnosis (larva).—(Modified from Wharton and Fuller, 1952: 41). Leg I with seven segments, legs II and III with six or seven segments; anterior, median projection of scutum absent; anteromedian scutal seta present or absent; paired submedian scutal setae absent.

Included genera.—Known from both larvae and postlarvae: *Ascoschöngastia* Ewing, *Blankaartia* Oudemans, *Cheladonta* Lipov-

sky *et al.*, *Doloisia* Oudemans, *Euschöngastia* Ewing, *Euschöngastoides* Loomis, *Guntherana* Womersley and Heaslip, *Heaslipia* Ewing, *Neoschöngastia* Ewing, *Pseudoschöngastia* Lipovsky, *Schöngastia* Oudemans, *Schoutedenichia* Jadin and Vercammen-Grandjean, *Speleocola* Lipovsky, *Trombicula* Berlese, *Walchia* Ewing, and *Walchiella* Fuller. Known only from larvae: *Anominalaspis* Brennan, *Babiangia* Southcott, *Endotrombicula* Ewing, *Gahrliepia* Oudemans, *Gateria* Ewing, *Giroudia* Vercammen-Grandjean, *Mackiena* Traub and Evans, *Myotrombicula* Womersley and Heaslip, *Novotrombicula* Womersley and Kohls, *Oenoschöngastia* Womersley and Kohls, *Riedlinia* Oudemans, *Sauracarella* Lawrence, *Schöngastiella* Hirst, *Tecomatlana* Hoffmann and *Womersia* Wharton. Known only from adults: *Ipotrombicula* Womersley and *Speotrombicula* Ewing.

Remarks.—Of the sixteen genera known only as larvae, nine are monotypic; only two of sixteen genera known from both larvae and postlarvae are monotypic. The two genera known only as adults are monotypic and are obviously based on single characters.

The subfamily Trombiculinae as represented here includes genera formerly placed in the subfamily Walchiinae (= Gahrliepiinae).

As postlarvae the genera are divisible into two groups. The genera *Euschöngastoides, Pseudoschöngastia,* and *Walchia* (and probably *Schoutedenichia*) share the following features: Cheliceral base with posterior tip elevated, area of articulation with basis capituli ventral; hypostome short, blunt, with about twenty short apical nude or nearly nude setae; pharynx marked with a reticulate pattern; scutum short and broad, mean ratio ASL/SB: about 1.2-1.7.

Remaining genera have the cheliceral base with posterior tip depressed, area of articulation with basis capituli ventral; hypostome elongated, tip usually pointed but sometimes blunt, with about eight apical nude setae; pharynx not marked with a reticulate pattern; scutum longer, mean ratio ASL/SB: 2.0 or greater (except *Guntherana* and *Doloisia*). However, the use of formal names for these groups would be premature.

Species studied by the writer are members of the genera *Blankaartia, Cheladonta, Euschöngastia, Euschöngastoides, Neoschöngastia, Pseudoschöngastia, Speleocola, Trombicula,* and *Walchia.* Descriptions of other postlarvae are sufficiently complete so that the remaining genera can be keyed out, except for *Ascoschöngastia* and *Walchiella,* and several subgenera. In the following discussions the genera seen by the writer will be presented first, and those not seen will follow.

KEY TO GENERA OF TROMBICULINAE (NYMPHS)

1. Leg I with a pair of distally trifurcate claws ... *Speotrombicula** p. 274
1'. Leg I with a pair of distally undivided claws ... 2
2. Scutum with a branched body seta at the base of the crista, in the sensillary area ... *Ipotrombicula** p. 273
2'. Scutum without a body seta in the sensillary area ... 3
3. Precoxal plates of coxa I present and separated, not fused in the midline to form a longitudinally divided sternum ... 4
3'. Precoxal plates of coxa I usually absent; if present they are fused in the midline to form a longitudinally divided sternum ... 6
4. Long and short body setae intermixed (American species with extremely elongated palpal claws) ... *Neoschöngastia* p. 231
4'. Adjacent body setae of similar lengths; palpal claws not unusually elongated ... 5
5. Sensillary area narrower (ratio ASL/SB: about 2 in nymphs) *Schöngastia** p. 274
5'. Sensillary area wide (ratio ASL/SB: about 1 in nymphs) *Guntherana** p. 272
6. Tarsus I with a stumplike process on dorsoapical margin ... 7
6'. Tarsus I without a stumplike process on dorsoapical margin ... 8
7. Tectal seta absent ... *Walchia* p. 268
7'. Tectal seta present ... *Schoutedenichia** p. 274
8. Cheliceral base unusually elongated distally (ratio BL/BH: about 4.0 in nymphs); cheliceral blades rather short, semilunar; palpal trochanter elongated ... *Cheladonta* p. 211
8'. Cheliceral base only rarely unusually elongated (ratio BL/BH: up to 3.6 in nymphs); cheliceral blades longer, shearlike; palpal trochanter not elongated ... 9
9. Hypostome short, blunt, with about twenty short apical nude or nearly nude setae; pharynx marked with a reticulate pattern ... 10
9'. Hypostome long, pointed, with about eight longer apical nude setae; pharynx indistinct ... 11
10. Tectal margin without serrations; sensilla stiff, thick to subclavate; mean ratio ASL/SB: about 1.7 ... *Pseudoschöngastia* p. 235
10'. Tectal margin with serrations; sensilla almost flagelliform, flexible; mean ratio ASL/SB: about 1.3 ... *Euschöngastoides* p. 226
11. Eyes present in front of and separated from sensillary area; sensilla completely nude ... *Blankaartia* p. 208
11' Eyes usually absent; when present, at the sides of and adjacent to sensillary area; sensilla with at least short basal branches ... 12
12. Tectal margin without teeth or serrations ... 13
12'. Tectal margin with teeth or serrations ... 14
13. Tectum large or small but hyaline, not developed into a sclerotized "nase" ... *Euschöngastia* p. 215
13'. Tectum large, an elongated triangular cone, not hyaline, developed into a conspicuous "nase" ... *Heaslipia** p. 273
14. Posterior body setae short and with compound branching *Speleocola* p. 238

* Specimens were not seen by the writer.

14'. Posterior body setae short or long but never with compound branching 15
15. Sensillary area narrow; mean ratio ASL/SB: 1.9-2.7 *Trombicula* p. 258
15'. Sensillary area wide; mean ratio ASL/SB: 0.7-1.2 *Doloisia** p. 271

Genus *Blankaartia* Oudemans

Blankaartia Oudemans, 1911, Ent. Ber., vol. 3, p. 123 (type *Trombidium niloticum Trägårdh*, 1904) (*adult*).
Trombicula (Blankaartia), Fuller and Wharton, 1951, Psyche, vol. 58, p. 87; Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 29; Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 42.
Trombicula (Trägårdhula) Berlese, 1912, Redia, vol. 8, p. 4 (type *Trombidium niloticum* Trägårdh, 1904).
Trägårdhula, Womersley, 1948, Trans. Roy. Soc. South Australia, vol. 72, p. 83; Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 114 *(post-larvae)*.
Pentagonella Thor, 1936, Zool. Anz., vol. 114, p. 30 (type *Trombidium ardeae* Trägårdh, 1904).
Trombicula (Megatrombicula) Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 432 (type *Trombicula alleei* Ewing, 1926).

Diagnosis (nymph).—(1) *Eyes 1/1, separated from sensillary area.* (2) Precoxal plates absent. (3) Body setae branched, not expanded, no compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting, with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum triangular, *somewhat sclerotized, with smooth margin;* with a single tectal seta. (11) Sensillary area triangular; mean ratio ASL/SB: 2.9-3.2. (12) Without branched body seta in sensillary area. (13) Sensilla flagelliform, long, *entirely nude.*

Additional features (nymph).—(14) Body size medium (about 0.8-0.9 mm. long), of usual shape. (15) Sternum pentagonal, closed behind. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral; base with posterior tip depressed. (18) Palpus stout, large; *distal portion of tibia unusually elongated;* palpal claw short, slightly curved; *two to seven accessory claws;* tarsus with about seven branched setae and four or five apical nude setae. (19) Hypostome with about twenty ventral branched setae. (20) Basis capituli of usual shape. (21) Crista narrow, elongated. (22) Sensillary area with basal plate of two bandlike halves; *bulla elongated anteriorly; carina apparently absent;* sensillary bases placed well lateral; anterior, lateral, and posterior ridges somewhat weak; ridges medial to sensillary bases present; apodeme normal. (23) About thirty parascutal setae.

* Specimens were not seen by the writer.

Remarks.—Fuller and Wharton (1951:85) have discussed the proper name for this group. I follow them in considering *Pentagonella* and *Megatrombicula* as synonyms. Womersley has persisted in using the name *Trägårdhula.*

Previously *Blankaartia* has been accommodated as a subgenus of *Trombicula* (except by Womersley, who uses generic status). The reasons appear to have been twofold; while *Blankaartia* postlarvae appear distinct, little is known of *Trombicula* postlarvae, and *Blankaartia* larvae are very similar to certain *Trombicula* larvae. This situation has not changed, except that more *Trombicula* postlarvae have become known.

I have decided to follow Womersley in giving generic status to this group. Nymphs of *Blankaartia* appear related to those of *Trombicula* but are amply distinct. The larvae are more closely similar but can apparently be separated (by keys to subgenera of *Trombicula* as given by several authors).

Distinctive features of *Blankaartia* appear to be primitive ones as well. The position of the eyes, the entirely nude sensilla, and the smooth tectal margin are leeuwenhoekiine characters. The numerous accessory claws are also found in the Trombidiidae. The scutum, while triangular, is distinct from that of *Trombicula* in possessing an elongated bulla and lacking a carina.

The diagnosis given above is based upon the two species *B. alleei* and *B. velascoi.* Additional postlarvae are known: *B. nilotica* and *B. peruviana* are known only as adults; postlarvae of *B. acuscutellaris* and *B. attenuata* have also been described. A single species, *B. ardeae,* is known only as the larva. Descriptions of known postlarvae may be found in Womersley, 1952, pages 314-323.

The generic diagnosis given above differs from descriptions of Womersley in an important respect. Womersley describes the tectum ("epistome") as bearing "fine denticulations." In specimens (including adults) of *B. alleei, B. attenuata* (adults only), and *B. velascoi,* examined by me, the tectal margin appears smooth. Womersley's drawing of *B. velascoi* shows the tectal margin as nearly smooth. The tectal margins of *B. acuscutellaris* and *B. nilotica* are illustrated as possessing more marked teeth. This character requires confirmation.

Womersley includes in *Trägårdhula* (= *Blankaartia*) the species *Trombicula japonica* (Tanaka), on the basis of Tanaka's description of eyes anterior to the sensillary area. However, Sasa (1953: 423) describes the nymph as lacking eyes, and places it in *Trombicula* (*Neotrombicula*), as do Philip and Fuller (1950:50). It is

evident that Womersley is dealing with a different form than is Sasa. I follow Philip and Fuller, and Sasa, and place *japonica* in *Trombicula* (*Neotrombicula*).

Besides *B. alleei* and *B. velascoi*, only *B. acuscutellaris* is known also as a nymph. Womersley (1952:317) describes the nymph of *acuscutellaris* but gives no characters to separate it from *alleei*. Michener (1946:434) presents a key which separates nymphs of *alleei* and *velascoi*.

Blankaartia alleei (Ewing) *New Combination*

(Figs. 22, 63, 171, 172, 208)

Trombicula alleei Ewing, 1926, Ent. News, vol. 37, p. 111 (*adult*).
Trombicula (*Megatrombicula*) *alleei*, Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 434 (*larva, nymph, adult*).
Trägårdhula alleei, Womersley, 1948, Trans. Roy. Soc. South Australia, vol. 72, p. 89 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 319 (*postlarvae*).
Trombicula (*Blankaartia*) *alleei*, Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 43.

Description of nymph.—Body: About 0.9 mm. long, color red. Eyes about 39 μ in diameter, color not known. Body setae normal, tips simple; posterior setae about 50 μ long. Sternum with about 10 setae. Measurements of tarsus I (1 specimen); TL: 224, TH: 117, TL/TH: 1.9.

Gnathosoma: Cheliceral base elongated, punctate; blade elongated but shearlike, nearly devoid of teeth (two tiny teeth present on one chela of single specimen). Cheliceral measurements (1 specimen); BL: 170, BH: 68, CL: 104, BL/BH: 2.5, BL/CL: 1.61. Palpus with dorsal femoral and genual setae with reduced branching, some nude; tibia with stalklike distal elongation bearing stout claw, setae nude, 3 accessory claws on small dorsal flange; tarsala not seen; tarsus with but 5 branched setae with reduced branching, 4 apical nude setae, arranged 2 inner, 2 outer. Setal counts (1 specimen); femur (obscured), genu: 14, tibia: 9, tarsus: 5.

Scutum: Lateral keels not seen. Crista very narrow. Sensillary area triangular but elongated anteriorly (apex of triangle long); bands of basal plate narrow; bulla prominent. Scutal measurements (1 specimen); ASL: 205, SB: 70, TS (obscured), SENS (obscured), ASL/SB: 2.9.

Remarks.—This description is based upon a single specimen reared by Dr. C. D. Michener.

Specimens examined.—One nymph, as follows: PANAMA. *Colón Province:* Santa Rosa, *Myiozetetes cajonensis*, November 11, 1945 (1 nymph, reared by C. D. Michener).

Blankaartia velascoi (Boshell and Kerr), *New Combination*

(Figs. 148, 169, 170, 206)

Trombicula velascoi Boshell and Kerr, 1942, Rev. Acad. Colombiana Cien. Exact., Fisico-Quim. Y Nat., vol. 5, p. 113 (*adult*).
Trombicula (Megatrombicula) velascoi, Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 438 (*larva, nymph, adult*).
Trägårdhula velascoi, Womersley, 1948, Trans. Roy. Soc. South Australia, vol. 72, p. 89 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 321 (*postlarvae*).
Trombicula (Blankaartia) velascoi, Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 44.

Description of nypmh.—Resembles *B. alleei* except as follows: Body: About 0.8 mm. long, color red. Eyes about 32 μ in diameter. Posterior body setae longer, about 90 μ long; branches short; tips simple, attenuated. Measurements of tarsus I (means of 4 specimens); TL: 208.0 ± 4.97, TH: 80.5 ± 2.06, TL/TH: 2.58 ± 0.0855.

Gnathosoma: Cheliceral blade with 21-30 small teeth (but one specimen without teeth). Cheliceral measurements (means of 3 specimens); BL: 165.3 ± 3.33, BH: 54.0 ± 0.00, CL: 88.2 ± 4.13, BL/BH: 3.0 ± 0.00, BL/CL: 1.97 ± 1.14. Palpal tibia with setae showing reduced branching; 4 to 7 accessory claws; tarsala about 13 μ long; tarsus with 5 apical nude setae arranged 3 inner, 2 outer. Setal counts (means of 3 specimens); femur: 8.17 ± 1.833, genu: 17.3 ± 2.892, tibia: range 4-7, tarsus: range 6-9.

Scutum: Measurements (means of 4 specimens); ASL: 155.8 ± 2.531, SB: 48.3 ±1.0308, TS: 56 (1 specimen), SENS: about 160, ASL/SB: 3.23 ± 0.0408.

Specimens examined.—Total 6 nymphs, as follows: PANAMA. *Canal Zone:* Juan Mina, *Myiozetetes similis,* October 3, 1945 (4 nymphs, reared by C. D. Michener); October 30, 1945 (1 nymph, reared by C. D. Michener). *Colón Province:* Gatuneillo, *Saltator,* October 30, 1945 (1 nymph, reared by C. D. Michener).

This material, as well as that of *B. alleei*, was kindly lent by Dr. W. V. Gertsch of the American Museum of Natural History.

Genus *Cheladonta* Lipovsky, Crossley and Loomis

Cheladonta Lipovsky, Crossley and Loomis, 1955, Jour. Kansas Ent. Soc., vol. 28, pp. 137-139 (type *Cheladonta micheneri* Lipovsky, Crossley and Loomis) (*larva*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae slightly expanded, branched, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical

stumplike process. (6) *Cheliceral base unusually elongated* (mean ratio BL/BH: about 4.0), *blade curved, semilunar-shaped.* (7) *Palpal trochanter elongated.* (8) Hypostome unusually elongated, pointed; with about eight short apical nude setae. (9) Pharynx indistinct. (10) Tectum nearly square, *hyaline,* with or without short teeth on margin, with one tectal seta. (11) *Sensillary area nearly reniform;* mean ratio ASL/SB: about 2.1. (12) Without branched body seta in sensillary area. (13) Sensilla straight to subclavate, branches variable.

Additional features (nymph).—(14) Body size medium (about 0.6-0.7 mm. long), elongated. (15) Sternum roughly triangular, closed behind. (16) *Tarsus I rounded.* (17) Articulating area of cheliceral base with basis capituli ventral, small; base with posterior tip depressed. (18) Palpus somewhat elongated; size moderate; distal portion of tibia not unusually elongated; claw moderate in size, slightly curved; two accessory claws; tarsus with about nine branched setae and one apical nude seta. (19) Hypostome with about ten to twenty ventral setae, *nude or nearly so.* (20) Basis capituli of usual shape. (21) Crista not narrowed, rodlike. (22) Sensillary area with basal plate of two rather broad bands; bulla reduced in size; carina absent; sensillary bases rather small, placed well forward; anterior, lateral, and posterior ridges present but no ridges medial to sensillary bases; *apodeme broad and prominent.* (23) About ten parascutal setae.

Remarks.—The genus *Cheladonta* was erected for the species *C. micheneri, C. crossi,* and *C. ouachitensis* from the United States, and *Neoschöngastia ikaoensis* from Japan and Korea. The foregoing diagnosis is based upon nymphs of *micheneri* and *ouachitensis,* and Sasa's (1953:426) description of the nymph of *ikaoensis.* Sasa illustrates no teeth on the tectal margin and states that the tectum is "without conspicuous denticles along anterior margin." Otherwise, his description agrees closely with the American species.

The characters distinctive for *Cheladonta* appear to be (6), (7), (16), (19), the shape of the sensillary area under (11), and the broad scutal apodeme under (22). In combination these characters indicate very distinctive forms; *Cheladonta* postlarvae are immediately recognized as such.

Larvae of *Cheladonta* seem close to *Euschöngastia* or *Neoschöngastia* but possess a key character in the ventral serrations on the cheliceral blade. In contrast, postlarvae appear far removed from other genera. The general appearance of the scutum suggests that

of *Neoschöngastia,* and indeed these two may be closely related. Vercammen-Grandjean (in correspondence) indicates rather close similarities between larvae of *Cheladonta* and larvae of certain species of *Schoutedenichia;* however, postlarvae of these two genera are markedly different.

KEY TO SPECIES OF CHELADONTA (NYMPHS)

1. Sensilla subclavate, greatest width near apex; cheliceral blade with teeth large, conspicuous ..... *micheneri* p. 213
1'. Sensilla slightly expanded but greatest width in midregion, tapered distally; cheliceral blade with teeth small to tiny 2
2. Tectal margin with obvious teeth ..... *ouachitensis* p. 214
2'. Tectal margin without obvious teeth ..... *ikaoensis.*

(See remarks on *Cheladonta,* p. 212.)

Cheladonta micheneri Lipovsky, Crossley and Loomis

(Figs. 42, 43, 85, 183, 184, 195, 196)

Cheladonta micheneri Lipovsky, Crossley and Loomis, 1955, Jour. Kansas Ent. Soc., vol. 28, p. 137 (*larva*).

Description of nymph.—Body: About 0.7 mm. long, color orange to white. Setae short, somewhat expanded, tips rounded; branches short and fine; posterior setae about 15 μ long. Sternal area roughly triangular in shape, distinctive; usually closed behind, occasionally with a trace of longitudinal division; with about 8 setae. Legs appear shortened. Measurements of tarsus I (means of 9 specimens); TL: 111.1 ± 2.010, TH: 72.2 ± 1.847, TL/TH: 1.56 ± 0.0294.

Gnathosoma: Cheliceral base peculiarly elongated, somewhat broadened near proximal end but tapering to apex; puncta few; blade short, semilunar, with about 11 teeth, mostly large and conspicuous; apodeme of blade strongly constricted. Cheliceral measurements (means of 8 specimens); BL: 121.3 ± 3.21, BH: 30.4 ± 0.460, CL: 34.0 ± 1.02, BL/BH: 4.0 ± 0.139, BL/CL: 3.58 ± 0.084. Palpi rather distinctive in appearance, because of elongated trochanters and genu wider than long; tarsala about 11 μ long; tarsus with apical nude seta on inner surface. Setal counts (means of 8 specimens); femur: 4.44 ± 0.333, genu: 8.25 ± 0.3134, tibia: range 4-6, tarsus: range 8-10.

Scutum: Sensillary area nearly reinform but anterior projection present; broad bands of basal plate well separated; apodeme often with irregular markings, furcate at posterior tip; bulla small, triangular; sensilla subclavate with short fine branches which lengthen towards tip. Scutal measurements (means of 9 specimens); ASL: 75.1 ± 1.67, SB: 35.4 ± 1.001, TS: 35.3 ± 0.833, SENS: about 70, ASL/SB: 2.14 ± 0.0377.

Remarks.—In culture, nymphs of *C. micheneri* ate active stages of collembolans and refused collembola eggs. As larvae they are rarely abundant upon hosts and large numbers were not available for culture purposes.

Specimens examined.—Total 12 nymphs, as follows: KANSAS. *Barber County:* 1 mi. W, 4½ mi. S. Aetna, *Cynomys ludovicianus*, July 27, 1952 (3 nymphs, reared DAC). *Douglas County:* 3 mi. W. Lawrence, *Sylvilagus floridanus*, November 12, 1949 (2 nymphs, reared LJL); Lawrence, *Neotoma floridana* nest, February 20, 1950 (4 nymphs, reared LJL). *Jefferson County:* ½ mi. E. 5½ mi. N Lawrence, *Peromyscus leucopus,* January 26, 1952 (1 nymph, reared DAC). *Norris County:* 2 mi. S Council Grove, *Peromyscus maniculatus,* May 31, 1950 (1 nymph, reared LJL).

Cheladonta ouachitensis Lipovsky, Crossley and Loomis

(Figs. 10, 44, 155, 200, 221)

Cheladonta ouachitensis Lipovsky, Crossley and Loomis, 1955, Jour. Kansas Ent. Soc., vol. 28, p. 139 *(larva).*

Description of nymph.—Resembles *C. micheneri* except as follows:

Body: About 0.6 mm. long, color not known. Posterior body setae about 20 μ long. Measurements of tarsus I (means of 3 specimens); TL: 108.7 ± 2.404, TH: 68.0 ± 2.517, TL/TH: 1.60 ± 0.0578.

Gnathosoma: Cheliceral blade with about 13 small or tiny teeth. Cheliceral measurements (means of 3 specimens); BL: 109.0 ± 2.64, BH: 27.3 ± 1.333, CL: 30.0 ± 1.15, BL/BH: 4.0 ± 0.116, BL/CL: 3.67 ± 0.1333. Palpus with tarsala about 8 μ long. Setal counts; femur (2 specimens): 3.5 ± 0.0000, genu (3 specimens): 7:83 ± 0.3342, tibia: range 5-6, tarsus: range 6-8.

Scutum: Sensilla slightly expanded in midregion but tapered distally, not subclavate; distal branches rather long. Scutal measurements (3 specimens); ASL: (not obtainable), SB: 31.6 ± 1.886, TS: 40.3 ± 4.19, SENS: about 80, ASL/SB: (not obtainable).

Remarks.—These nymphs were reared in a culture of *Trombicula (Neotrombicula).* Re-examination of records showed that larvae of *C. ouachitensis* were also taken from the host; there is little doubt that these nymphs are *ouachitensis.*

This species differs from *C. micheneri* in having smaller, more numerous cheliceral teeth and in the nature of the sensilla. Judging from Sasa's description (1953:426), *C. ouachitensis* is very similar to *C. ikaoensis.*

Specimens examined.—Total 3 nymphs, as follows: ARKANSAS. *Polk County:* 2 mi. NE Mena, *Cryptotis parva,* March 3, 1951 (3 nymphs, reared LJL).

Genus *Euschöngastia* Ewing

Euschöngastia Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 293 (type *Schöngastia sciuricola* Ewing) (= *Euschöngastia americana* Ewing) (*larva*).

Diagnosis (*nymph*).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae branched, variable; tips of posterior setae often with tiny branches, *sometimes compound;* adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting; with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum triangular, *hyaline, with margin smooth;* with one tectal seta. (11) Sensillary area triangular to transverse-oval in shape; mean ratio ASL/SB: 2.1-2.7. (12) Without branched body seta in sensillary area. (13) Sensilla thick, somewhat straight but not subclavate; branches short.

Additional features (*nymph*).—(14) Body size small to large (0.4-1.0 mm. long), of usual shape. (15) Sternum closed behind, roughly pentagonal to elongated in shape. (16) Tarsus I usually elongated, sometimes nearly rounded. (17) Articulating area of cheliceral base with basis capituli ventral; base with posterior tip depressed. (18) Palpus usually stout, moderate in size, slightly curved; two accessory claws; tarsus with about nine branched setae and four or five apical nude setae. (19) Hypostome with about ten to twenty ventral branched setae. (20) Basis capituli of usual shape, rarely broadened. (21) Crista a narrow rod. (22) Sensillary area with basal plate of two halves; bulla present, sometimes reduced; carina present; sensillary bases placed well lateral; anterior, lateral, and posterior ridges present but often weak; ridges medial to sensillary bases weak; *toothlike projections often present at front angles of sensillary area;* apodeme usually reduced. (23) About eight to fourteen parascutal setae.

Remarks.—This description is based entirely on the species studied by the writer. Other postlarvae have been described. *Schöngastia samoaensis* Womersley and *Microtrombidium westralensis* Womersley, both known only as adults, were placed in *Schöngastia* (*Ascoschöngastia*) (= *Euschöngastia*) by Womersley (1952:

423, 383). Also, Womersley described reared nymphs of *Neoschöngastia lanius* Radford, *Schöngastia audyi* Womersley, *N. kohlsi* Radford, *N. mutabilis* Gater, and *S. nadchatrami* Womersley and placed them in *Schöngastia* (*Ascoschöngastia*). Wharton (1946: 159, 162) gives excellent descriptions of the nymph and adult of *Euschöngastia indica* (Hirst). More recently, Domrow (1955:57, 130) has described the nymphs of *Euschöngastia smithi* (Womersley) and *E. perameles* (Womersley). *Trombicula algerica* Andre, known only as adult, was placed in *Euschöngastia* by Wharton and Fuller (1952:73).

The species known only as adult could as well be accommodated in *Trombicula* as in *Euschöngastia* but their final placement will require more careful descriptions. The species known as both larva and nymph must be more carefully considered.

The only useful character for separating nymphs of *Euschöngastia* from those of *Trombicula* is the nature of the tectum. In *Euschöngastia,* the tectal margin is smooth; in *Trombicula,* the tectal margin has serrations or teeth. In the larval stage a single easily discernible character separates these two genera; *Euschöngastia* has expanded sensilla while *Trombicula* has flagelliform sensilla. Otherwise, the two genera appear similar in both stages. The nymphs of species of *Euschöngastia* as described by Domrow, Wharton, and Womersley all possess serrations on the tectal margin and thus in that key couplet would fall into *Trombicula.* The larvae, however, have expanded sensilla and so would be placed in *Euschöngastia.*

Three of these nymphs, *Euschöngastia indica, E. perameles,* and *E. smithi,* would apparently key out to *Euschöngastoides* rather than *Trombicula* or *Euschöngastia;* these species are further discussed under *Euschöngastoides.* The remainder, as described by Womersley, would seemingly key to *Trombicula.* In the illustrations of these species, the tectum is shown as rounded and with fine serrations. Possibly these are in reality absent. Also, Womersley's nymphs are Asiatic while mine are American; possibly there are real group differences between them.

The genus *Euschöngastia* contains a broad assemblage of species and is long overdue for revision and probable recognition of other genera for some species groups. Also, its relations with *Trombicula* must be critically surveyed. Any generic separation based upon a single character is likely to be artificial.

KEY TO SPECIES OF EUSCHÖNGASTIA (NYMPHS)

1. Posterior body setae ending in single long, fine, attenuated tips, never with minute branches near tips ..... *pipistrelli* p. 222
1′. Posterior body setae ending in one or (usually) more small or minute branches 2
2. Sensilla with apical portions nude and attenuated, or with short branches very sparse on apical portions 3
2′. Sensilla with short branches along entire length 4
3. Sternal area elongated-rectangular ..... *jonesi* p. 220
3′. Sternal area nearly pentagonal, not elongated posteriorly, *trigenuala* p. 225
4. One or two rather inconspicuous toothlike projections on anterior margin of sensillary area directly in front of sensillary bases 5
4′. Three or four prominent, broad toothlike projections arising from most of anterior margin of sensillary area 7
5. Larger species, ASL about 120 μ, TS about 50 μ, BL about 135 μ ..... *setosa* p. 223
5′. Smaller species; ASL about 80-90 μ, TS about 25-30 μ, BL about 100 μ 6
6. Posterior body setae ending in blunt tips with one or two short, minute, thick branches ..... *cynomyicola* p. 218
6′. Posterior body setae each ending in attenuated tip divided into two to four short, attenuate branches ..... *criceticola* p. 217
7. Tips of posterior body setae slightly enlarged and ending in numerous short minute compound branches; one (rarely two) lateral branch at each tip characteristically enlarged and prominent ..... *peromysci* p. 221
7′. Tips of posterior body setae not enlarged, ending in two or three short, often compound branches; without such a modified lateral branch at tips ..... *diversa* p. 219

Euschöngastia criceticola Brennan

(Figs. 46, 70, 130, 131, 150, 217)

Euschöngastia criceticola Brennan, 1949, Jour. Parasit., vol. 34, p. 473 *(larva)*; Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1340 *(larva)*.

Description of nymph.—Body: About 0.7 mm. long, color yellow to orange. Body setae branched as usual; tips of posterior setae ending in 2 to 4 short attenuated branches; posterior setae about 60 μ long. Sternum roughly pentagonal, with about 8 setae. Measurements of tarsus I (means of 8 specimens); TL: 118.1 ± 1.86, TH: 51.0 ± 1.53, TL/TH: 2.34 ± 0.0962.

Gnathosoma: Basis capituli of usual shape. Cheliceral base somewhat stout, puncta few; blade stout, shearlike, with about 13 teeth of varying sizes. Cheliceral measurements (means of 10 specimens); BL: 100.7 ± 1.764, BH: 37.5 ± 1.241, CL: 46.8 ± 0.554, BL/BH: 2.73 ± 0.120, BL/CL: 2.14 ± 0.043. Palpus normal, rather small; tarsala about 11 μ long; tarsus with 3 inner, 1 outer

apical nude setae. Setal counts; femur (6 specimens): 3:67 ± 0.3587, genu (7 specimens): 7.43 ± 0.5279, tibia: range 4-5, tarsus: range 8-9.

Scutum: Tectum moderate in size. Sensillary area with basal plate of two narrow bands; apodeme much reduced; bulla triangular; carina thin; ridges weak; anterior margin often with one or two small toothlike projections directly anterior to sensillary bases; sensilla slightly thickened but flexible, with short branches along entire length. Scutal measurements (means of 7 specimens); ASL: 81.6 ± 2.861, SB: 36.8 ± 1.031, TS: 27.0 ± 1.448, SENS: about 100, ASL/SB: 2.14 ± 0.0645.

Remarks.—Euschöngastia criceticola appears to be a widespread chigger in western North America (see Loomis, 1956:1341). There may be more than one form of larva considered under this name. The nymphs described here are associated with the larval form treated by Loomis (1956:1340).

This species was reared on three occasions. There are no records of feeding by the nymphs, but since some adults were obtained the nymphs evidently fed. The food was probably collembola eggs which were added to the cultures as food material.

Specimens examined.—Total 41 nymphs, as follows: KANSAS. *Barber County:* 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus,* April 11, 1949 (39 nymphs, reared LJL); 4 mi. S Aetna, *Neotoma micropus,* October 6, 1951 (1 nymph, reared LJL). *Russell County:* 5 mi. N, 2 mi. E Graham, *Peromyscus maniculatus,* April 27, 1952 (1 nymph, reared DAC).

Euschöngastia cynomyicola Crossley and Lipovsky

(Figs. 50, 67, 212)

Euschöngastia cynomyicola Crossley and Lipovsky, 1954, Proc. Ent. Soc., Washington, vol. 46, pp. 240-243 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1342 (*larva*).

Description of nymph.—Resembles *E. criceticola* except as follows:

Body: About 0.4 mm. long, color not known. Tips of posterior body setae blunt, ending in one or two minute, but thick, branches; posterior setae about 35 μ long. Sternum with about 6 setae. Measurements of tarsus I (means of 10 specimens); TL: 113.0 ± 5.34, TH: 53.3 ± 1.044, TL/TH: 2.11 ± 0.0722.

Gnathosoma: Cheliceral base stout; blade normal, shearlike, with about 18 small to tiny teeth. Cheliceral measurements (means of 10 specimens); BL: 101.6 ± 2.945, BH: 41.5 ± 0.969, CL: 48.9

± 1.197, BL/BH: 2.46 ± 0.0748, BL/CL: 2.08 ± 0.029. Palpus rather stout, tarsala about 9 μ long. Setal counts (means of 11 specimens); femur: 8.45 ± 0.3763, genu: 9.85 ± 0.6012.

Scutum: Measurements (means of 10 specimens); ASL: 86.8 ± 3.339, SB: 42.4 ± 0.897, TS: 29.6 ± 0.653, SENS: about 110, ASL/SB: 2.05 ± 0.0521.

Remarks.—This species is very similar to, although somewhat smaller than, *Euschöngastia criceticola.* As larvae the two are readily separable on several characters. *Euschöngastia cynomyicola* was cultured once. No records of feeding are available, and no adults were obtained from the culture. Evidently the nymphs either refused the collembolans and their eggs, or these were inadequate food materials.

Specimens examined.—Total 12 nymphs, as follows: NEBRASKA. *Hitchcock County:* 4 mi. E Stratton, *Cynomys ludovicianus,* August 8, 1949 (12 nymphs, reared LJL).

Euschöngastia diversa Loomis

(Figs. 49, 215)

Euschöngastia diversa Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1337 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color orange to yellow. Body setae resembling those of *E. criceticola* but posterior setae ending in 2 to 4 short branches, these sometimes compound; posterior setae about 50 μ long. Sternum roughly pentagonal, with about 10 setae. Measurements of tarsus I (means of 6 specimens); TL: 124.0 ± 3.85, TH: 66.3 ± 1.41, TL/TH: 1.87 ± 0.0212.

Gnathosoma: Cheliceral base stout, puncta numerous; blade stout, shortened, shearlike, with about 13 large to small teeth. Cheliceral measurements (means of 6 specimens); BL: 102.0 ± 3.507, BH: 43.3 ± 1.282, CL: 52.3 ± 1.308, BL/BH: 2.38 ± 0.1046, BL/CL: 2.00 ± 0.0516. Palpus somewhat stout, accessory claws somewhat shortened; tarsala about 10 μ long; tarsus with 3 inner, 1 outer apical nude setae. Setal counts; femur (3 specimens); 5.0 ± 0.000, genu (4 specimens): 8.75 ± 0.595, tibia: range 4-6, tarsus: range 9-10.

Scutum. Tectum moderate in size, seta elongate. Sensillary area with basal plate of two widely separated bandlike halves; apodeme much reduced or absent; bulla small, triangular; carina prominent, often doubled posteriorly; strong ridges anterior to and posterior to sensillary bases, other ridges weak; anterior margin of sensillary

area with three or four broad, prominent, toothlike projections covering most of margin; sensillum like that of *E. cricetícola.* Scutal measurements (means of 6 specimens); ASL: 95.8 ± 4.489, SB: 36.3 ± 1.606, TS: 30.0 ± 0.894, SENS: about 125, ASL/SB: 2.65 ± 0.1335.

Remarks.—As both larva and postlarva, *E. diversa* is very similar to *E. peromysci.* Nymphs of these two species are separable by the nature of the tips of the posterior body setae, as indicated in the key to species. This character varies in both species. Many specimens of *E. diversa* have the tips of these setae divided into several short attenuate branches, but others have these branches compoundly branched. When a lateral branch arises very near the tip, the setae resemble those of *E. peromysci.* In none of the material examined was there any difficulty in separating these two species by this character, however.

This species was reared on several occasions. The nymphs utilized collembolan eggs as food, and several adults were obtained.

Specimens examined.—Total 87 nymphs, as follows KANSAS. *Douglas County:* Lawrence, *Neotoma floridana,* December 9, 1949 (26 nymphs, reared LJL); 3 mi. W Lawrence, *Neotoma floridana,* March 2, 1949 (1 nymph, reared LJL) and March 5, 1949 (53 nymphs, reared LJL); 4 mi. N, 1 mi. E Lawrence, *Neotoma floridana,* December 9, 1948 (1 nymph, reared LJL); 2 mi. S, 2 mi. W Pleasant Grove, *Neotoma floridana,* March 4, 1949 (2 nymphs, reared LJL). *Johnson County:* 2 mi. W, 1 mi. N Lenexa, *Sylvilagus floridanus,* November 18, 1953 (3 nymphs, reared RBL). *Miami County:* 2 mi. W, 1 mi. S Louisburg, *Sylvilagus floridanus,* November 24, 1953 (1 nymph, reared RBL, idet. by larval skin).

Euschöngastia jonesi Lipovsky and Loomis

(Figs. 26, 64, 108, 109, 153, 216)

Euschöngastia jonesi Lipovsky and Loomis, 1954, Jour. Parasit., vol. 40, pp. 407-410 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1332-1333 (*larva*).

Description of nymph.—Body: About 0.7 mm. long, color yellow to white. Body setae like those of *E. cricetícola,* but posterior setae ending in tips of 2 to 4 short branches, which are surpassed by a long semiterminal lateral branch; posterior setae about 90 μ long. Sternum elongated-rectangular, with about 8 setae. Measurements of tarsus I (means of 7 specimens); TL: 147.0 ± 4.999, TH: 71.3 ± 1.340, TL/TH: 2.06 ± 0.0429.

Gnathosoma: Basis capituli rather short, broad. Cheliceral base somewhat stout, puncta numerous; blade shearlike but thinner, and

elongated, with about 20 small to tiny teeth. Cheliceral measurements (means of 7 specimens); BL: 127.3 ± 4.279, BH: 50.0 ± 1.309, CL: 68.0 ± 1.448, BL/BH: 2.56 ± 0.2243, BL/CL: 1.87 ± 0.3394. Palpus normal, rather large; tarsala about 15 μ long; tarsus with 4 or 5 apical nude setae. Setal counts (means of 7 specimens); femur: 4.5 ± 0.2886, genu: 11.64 ± 0.8360, tibia: range 4-6, tarsus: range 8-10.

Scutum: Tectum moderate in size; seta elongated. Sensillary area with basal plate normal, apodeme much reduced; bulla triangular; carina prominent; strong ridges anterior and posterior to sensillary bases; sensilla slightly thickened but flexible; short basal branches numerous but branches on distal portion few, and short. Scutal measurements (means of 7 specimens); ASL: 128.5 ± 2.79, SB: 43.6 ± 0.922, TS: 47.0 ± 1.964, SENS: about 150, ASL/SB: 2.67 ± 0.0334.

Remarks.—Euschöngastia jonesi is similar to *E. pipistrelli* particularly in details of the scutum. The two species are separable by characters of the gnathosoma but most readily by the nature of the tips of the posterior body setae: *E. jonesi* has setae ending in several short branches, while *E. pipistrelli* has setae ending in a single long branch. The two species are also similar as larvae.

The nymphs were readily maintained in culture. They fed upon collembola eggs.

Specimens examined.—Total 7 nymphs, as follows: KANSAS. *Barber County:* 4 mi. S Aetna, *Peromyscus maniculatus,* October 7, 1951 (1 nymph, reared DAC). *Cowley County:* 2 mi. E Rock, *Peromyscus leucopus,* March 7, 1953 (6 nymphs, reared DAC, idet. by larval skins; reared from larvae associated with the type series).

Euschöngastia peromysci (Ewing)

(Figs. 48, 66, 104, 105, 152, 214)

Schöngastia peromysci Ewing, 1929, Ent. News, vol. 40, p. 296 (*larva*).
Euschöngastia peromysci Fuller, 1948, Bull. Brooklyn Ent. Soc., vol. 43, p. 108 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1334-1335 (*larva*).

Description of nymph.—Resembles *E. diversa* except as follows:

Body: Posterior body setae ending in slightly expanded tips, which give rise to several short compound branches, each seta with a thickened subterminal lateral branch surpassing the tip; posterior setae about 35 μ long. Sternum with about 6 setae. Measurements of tarsus I (means of 9 specimens); TL: 133.1 ± 0.588, TH: 73.1 ± 0.7536, TL/TH: 1.83 ± 0.0167.

Gnathosoma: Cheliceral blade with about 18 rather small to tiny teeth. Cheliceral measurements (means of 9 specimens); BL: 115.4 ± 4.176, BH: 48.0 ± 0.957, CL: 60.3 ± 0.965, BL/BH: 2.41 ± 0.0588, BL/CL: 1.88 ± 0.325. Palpus with tarsala about 12 μ long. Setal counts (means of 9 specimens); femur: 3.83 ± 0.2041, genu: 10.0 ± 0.4961, tibia: range 4-5.

Scutum: Measurements (means of 10 specimens); ASL: 105.9 ± 1.645, SB: 43.4 ± 0.499, TS: 38.6 ± 1.335, SENS: about 145, ASL/SB: 2.44 ± 0.0445.

Remarks.—This species shows the most extreme modification of the tips of the posterior body setae. The minute compound branches of the tip are often distributed along the prominent lateral branch, for about half of its length. The characteristics of these setae are adequate for recognition of the species. A specimen from Shelby County, Tennessee, shows a deviate condition: Two instead of one prominent subterminal branches, forming about a ninety-degree angle. Larvae from which this nymph was reared are typical *peromysci*. Since *E. peromysci* is primarily an eastern species, this two-spined tip may be more characteristic.

In culture, nymphs of *E. peromysci* ate collembolan eggs.

Specimens examined.—Total 19 nymphs, as follows: KANSAS. *Cowley County:* 2 mi. E Rock, *Peromyscus leucopus,* March 7, 1953 (7 nymphs, reared DAC, idet. by larval skins). *Douglas County:* Lawrence, *Sylvilagus floridanus,* Lawrence, November 12, 1949 (1 nymph, reared LJL), and *Neotoma floridana,* March 30, 1949 (2 nymphs, reared LJL); 5 mi. N, 1 mi. E Lawrence, *Neotoma floridana,* February 18, 1950 (1 nymph, reared LJL); 2 mi. S, 2 mi. W Pleasant Grove, *Neotoma floridana,* March 4 and 5, 1949 (3 nymphs, reared LJL). *Jefferson County:* 5½ mi. N Lawrence, *Peromyscus leucopus,* January 25, 1952 (2 nymphs, reared DAC). *Johnson County:* Roeland Park, *Sylvilagus floridanus,* November 10, 1953 (2 nymphs, reared RBL). TENNESSEE. *Shelby County: Peromyscus leucopus,* January 31, 1954 (1 nymph, reared DAC, idet. by larval skin).

Euschöngastia pipistrelli Brennan

(Figs. 28, 225)

Euschöngastia pipistrelli Brennan, 1947, Jour. Parasit., vol. 33, p. 249 *(larva);* Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1331-1332 *(larva).*

Description of nymph.—Resembles *E. joncsi,* except as follows:

Body: About 1.0 mm. long, color not known. Body setae like those of *E. cricetícola,* with branches rather long; tips single, long, attenuated; posterior setae about 105 μ long; posterior setae mark-

edly longer than dorsal subposterior setae. Sternum roughly pentagonal, with about 6 setae. Measurements of tarsus I (means of 4 specimens); TL: 196.0 ± 5.788, TH: 81.3 ± 1.109, TL/TH: 2.40 ± 0.410.

Gnathosoma: Cheliceral base apparently without puncta; blade of usual shearlike shape, with about 25 small to tiny teeth. Cheliceral measurements (means of 4 specimens); BL: 129.5 ± 3.97, BH: 55.0 ± 2.35, CL: 67.5 ± 2.33, BL/BH: 2.38 ± 0.233, BL/CL: 1.93 ± 0.008. Palpus with tarsala about 13 μ long; tarsus with 3 inner, 1 outer apical nude setae. Setal counts (means of 4 specimens); femur: 7.88 ± 1.0784, genu: 15.75 ± 1.4790, tibia: range 4-7, tarsus: range 10-13.

Scutum: Sensillum resembling that of *E. criceticola.* Scutal measurements (means of 3 specimens); ASL: 141.3 ± 2.03, SB: 54.8 ± 0.629, TS: 41.0 ± 2.000, ASL/SB: 2.60 ± 0.0577.

Remarks.—Euschöngastia pipistrelli is restricted in the larval stage to bats, while its closest relative, *E. jonesi,* occurs on other mammals as well. It seems logical to expect that the nymphal stage of a bat parasite, particularly a cave bat, would possess morphological features indicating adaptation to a cave habitat. However, *E. pipistrelli* resembles other species of *Euschöngastia* more closely than does *E. jonesi,* which can evidently persist in caves or in other habitats.

The larval forms of both species appear similar to the type of the genus, *E. sciuricola;* Loomis placed them in the subgenus *Euschöngastia.*

Specimens examined.—Total 4 nymphs, as follows: OKLAHOMA. *Adair County:* 5 mi. S. Kansas border (9½ S Aetna, Kansas), *Pipistrellus subflavus,* March 5, 1950 (4 nymphs, reared LJL).

Euschöngastia setosa (Ewing)

(Figs. 27, 29, 65, 102, 103, 156, 213)

Trombicula setosa Ewing, 1937, Proc. Biol. Soc. Washington, vol. 50, pp. 170-171 *(larva).*

Euschöngastia setosa, Fuller, 1948, Bull. Brooklyn Ent. Soc., vol. 43, p. 103 *(larva);* Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1329 *(larva).*

Description of nymph.—Body: Large, about 1.0 mm. long, color pale orange. Body setae like those of *E. diversa;* short branches at tip never with compound branching; posterior setae about 55 μ long. Sternum roughly pentagonal, with about 8 setae. Measurements of tarsus I (means of 5 specimens); TL: 174.0 ± 5.162, TH: 72.8 ± 2.834, TL/TH: 2.04 ± 0.0610.

Gnathosoma: Cheliceral base of usual shape, punctate; blade shearlike, with about 22 small teeth. Cheliceral measurements (means of 9 specimens); BL: 136.1 ± 3.116, BH: 53.2 ± 1.128, CL: 73.6 ± 1.987, BL/BH: 2.57 ± 0.0527, BL/CL: 1.86 ± 0.0176. Palpus large and stout; tarsala about 14 μ long; tarsus with 4 or 5 apical nude setae. Setal counts; femur (6 specimens): 18.5 ± 0.4831, genu (8 specimens): 9.94 ± 0.6371, tibia: range 5-8, tarsus: range 9-11.

Scutum: Tectum large, seta long. Sensillary area with basal plate of rather characteristic shape; apodeme reduced; bulla triangular; carina thin but prominent; strong ridges anterior and posterior to sensillary bases; other ridges weak; anterior margin of sensillary area with 2 (occasionally 1) elongated, rather characteristic toothlike projections directly in front of sensillary bases; sensillum like that of *E. criceticola*. Scutal measurements (means of 8 specimens); ASL: 123.0 ± 4.957, SB: 46.2 ± 1.172, TS: 49.5 ± 2.044, SENS: about 135, ASL/SB: 2.69 ± 0.0639.

Remarks.—Of the species considered here, *E. setosa* seems to be the most closely related to the type of the genus, *E. sciuricola*, judging from their larvae. Nymphs of *sciuricola* are unknown.

Several characters which separate *E. setosa* from other *Euschöngastia* species involve size; *E. setosa* is the largest of these nymphs. Otherwise some scutal details appear distinctive, as noted above.

In culture, nymphs of *E. setosa* ate Collembola eggs. Several adults were obtained from the cultures.

Specimens examined.—Total 22 nymphs, as follows: ARKANSAS. *Polk County:* 2 mi. NE Mena, *Cryptotis parva*, March 3, 1951 (1 nymph, reared LJL). KANSAS. *Barber County:* 4 mi. S Aetna, *Neotoma micropus*, October 6, 1951 (1 nymph, reared DAC), and *Peromyscus leucopus*, October 7, 1951 (1 nymph, reared DAC); 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus*, April 11, 1949 (4 nymphs, reared LJL); 5 mi. S Sun City, *Neotoma micropus*, April 12, 1949 (1 nymph, reared LJL). *Cowley County:* 2 mi. E Rock, *Peromyscus leucopus*, March 7, 1953 (1 nymph, reared DAC, idet. by larval skin). *Douglas County:* 1 mi. N, 5 mi. E Lawrence, *Neotoma floridana*, November 23, 1951 (1 nymph, reared DAC). *Johnson County:* Roeland Park, *Sylvilagus floridanus*, November 10, 1953 (9 nymphs, reared RBL); 2 mi. N, 1 mi. W Lenexa, *Sylvilagus floridanus*, November 18, 1954 (2 nymphs, reared RBL). *Russell County:* 5 mi. N, 2 mi. E Graham, *Peromyscus maniculatus*, April 27, 1952 (1 nymph, reared DAC).

Euschöngastia trigenuala Loomis

(Figs. 45, 68, 120, 121, 151, 192, 220)

Euschöngastia trigenuala Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1343 (*larva*).

Description of nymph.—Body: About 0.8 mm. long, color white. Setae somewhat expanded, with fine branches; tips rounded, with 2 or 3 shorter branches; posterior setae markedly longer than dorsal subposterior setae; posterior setae about 85 μ long. Sternum roughly pentagonal, with about 6 setae. Measurements of tarsus I (means of 8 specimens); TL: 119.3 ± 2.058, TH: 56.4 ± 1.252, TL/TH: 2.14 ± 0.0497.

Gnathosoma: Cheliceral base stout, puncta numerous; blade stout, shearlike, apodeme of blade markedly constricted; with about 13 rather large, flat teeth. Cheliceral measurements (means of 10 specimens); BL: 98.0 ± 1.361, BH: 41.2 ± 0.743, CL: 53.8 ± 1.104, BL/BH: 2.38 ± 0.0133, BL/CL: 1.81 ± 0.0233. Palpus stout, claw somewhat thin; tarsala about 14 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 10 specimens); femur: 4.45 ± 0.1740, genu: 8.65 ± 0.3078, tibia: range 4-6, tarsus: range 9-10.

Scutum: Tectum moderate in size. Sensillary area with basal plate of two bands as usual; apodeme much reduced; bulla triangular; carina thin; rather strong ridges anterior to and posterior to sensillary bases; other ridges weak; anterior margin sometimes with inconspicuous toothlike projections directly in front of sensillary bases; sensilla slightly thickened but flexible, with branches numerous on basal half but distal one third to one fourth entirely nude, attenuated. Scutal measurements (means of 10 specimens); ASL: 81.8 ± 1.597, SB: 37.2 ± 0.646, TS: 27.8 ± 1.236, SENS: about 116, ASL/SB: 2.21 ± 0.0407.

Remarks.—The closest relatives of *E. trigenuala* are not obvious. As both larva and nymph, the species has several distinctive features but these are not so striking as to suggest that *E. trigenuala* is far removed from the other species. Nymphs of *trigenuala* are easily recognized by the nude, tapered tip of the sensillum. Loomis (1956-1344) shows that larvae of *E. trigenuala* seem to prefer fossorial mammals, suggesting that the postlarvae may live in the subterranean burrows. No nymphs were reared from truly fossorial hosts.

Specimens examined.—Total 17 nymphs, as follows: KANSAS. *Douglas County:* 1 mi. E, 5 m. N Lawrence, *Microtus ochrogaster*,

February 20, 1952 (4 nymphs, reared DAC). *Johnson County:* 2 mi. N, 1 mi. W Lenexa, *Microtus ochrogaster,* April 2, 1954 (1 nymph, reared DAC). *Lyon County:* 2 mi. S Chalk, *Perognathus hispidus,* May 31, 1950 (10 nymphs, reared LJL). *Russell County:* 9 mi. S Russell, *Peromyscus maniculatus,* April 26, 1952 (1 nymph, reared DAC). TENNESSEE. *Shelby County:* 6 mi. N Memphis, *Microtus pinetorum,* February 2, 1954 (1 nymph, reared DAC, idet. by larval skin).

Genus *Euschöngastoides* Loomis, New Status

Trombicula (*Euschöngastoides*) Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, p. 924 (type *Trombicula (Euschöngastoides) hoplai* Loomis) *(larva).*

Diagnosis (*nymph*).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae branched, not expanded, tips variable; without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome short, blunt, with about twenty short apical nude or nearly nude setae.* (9) *Pharynx marked with a reticulate pattern.* (10) Tectum broad, hyaline, *with small serrations on margin,* and with one small tectal seta. (11) *Sensillary area wide;* mean ratio ASL/SB: 1.2-1.3. (12) Without branched body seta in sensillary area. (13) Sensilla almost flagelliform but slightly thickened, with branches.

Additional features (*nymph*).—(14) Body size medium (about 0.6 mm. long), of usual shape. (15) Sternum roughly rectangular, closed behind. (16) Tarsus I but slightly elongated. (17) *Articulating area of cheliceral base with basis capituli posterior; base with posterior tip elevated.* (18) Palpus stout, small; distal portion of tibia not unusually elongated; claw slightly curved, moderate in size; two accessory claws; tarsus with five to seven branched setae and *two apical nude setae.* (19) Hypostome with about ten ventral branched setae. (20) Basis capituli short, broad. (21) Crista short, narrow. (22) Sensillary area with basal plate of two well-separated halves; bulla triangular, moderate in size; carina absent; sensillary bases placed well lateral; ridges weak, apodeme apparently absent. (23) About ten parascutal setae.

Remarks.—Euschöngastoides was erected by Loomis as a subgenus of *Trombicula* for *T. hoplai* Loomis. At that time Loomis noted that the affinities of *T. hoplai* appeared to be with certain species of *Euschöngastia* rather than with other species of *Trom-*

bicula, despite the fact that the sensilla of *T. hoplai* (as larva) are not expanded. The species of *Euschöngastia* which are particularly similar are *E. finleyi* Crossley, *E. lacerta* Brennan, and *E. loomisi* Crossley and Lipovsky. Nymphs of *E. loomisi* were obtained. It became evident that *E. loomisi* and *T. hoplai* were very similar in the nymphal as well as in the larval stage, and that the nymphs were abundantly distinct from those of other species of *Trombicula* and *Euschöngastia.*

This is certainly not the first instance of similar larval forms being separated in the two genera *Trombicula* and *Euschöngastia* on the basis of difference in sensilla (see Audy, 1954:133 concerning confusion of larvae of *T. munda* and *E. indica*). In the present case, however, the nymphs have been reared, and have been found to show strong similarities to each other and appear to have affinities with different genera from those in which the larvae were placed.

These two species present a taxonomic dilemma. To leave them in the genera where they were originally placed would be in effect to ignore evidence of the postlarval stages, not only by separating two very similar nymphs but by placing them with groups which are markedly different. To place the species on postlarval evidence alone (perhaps in *Pseudoschöngastia,* nymphs of which are quite similar) would be to ignore evidence from the larval stage, in particular the nature of the sensilla, which separates the two major genera *Trombicula* and *Euschöngastia.* After careful consideration it appears that the flaw must lie in the rigid application of the single larval character, flagelliform sensilla versus expanded sensilla. Even in the larval stage the two species are similar except in the sensilla. The solution which does the least violence to both systems of classification appears to be the recognition of full generic status for *Euschöngastoides* and the inclusion of *E. loomisi* in that genus.

The genus *Euschöngastoides* will be very difficult to recognize in the larval stage until more species have been reared and a much better understanding of its limits obtained. It is proposed that for the time being no species be placed in this genus on the evidence of either larval or postlarval stages alone.

The relationships of the genus *Euschöngastoides* appear to be with *Pseudoschöngastia* and *Walchia.* Together, these three genera are separable from other trombiculine genera by the following diagnostic characters: (8) Hypostome short, blunt, with about twenty short apical nude or nearly nude setae. Other genera have

the hypostome longer, usually pointed, with about eight apical nude setae. (9) Pharynx marked with a reticulate pattern. In other genera the pharynx is unmarked. (11) Mean ratio ASL/SB: 1.2-1.7. In other genera the mean ratio ASL/SB is 2.0 or greater (except *Guntherana* and *Doloisia*, as described by other authors). (17) Articulating area of cheliceral base with basis capituli posterior, base with posterior tip elevated. In other genera the articulating area is on the ventral surface rather than across the posterior end. The posterior tip of the cheliceral base is depressed. There are several additional characters which indicate relationship between these three genera. As previously discussed, these genera may form a valid subfamily, but since larvae of *Euschöngastoides* are at present not separable from those of *Trombicula* and *Euschöngastia*, recognition of such a subfamily seems impractical.

The genus *Schoutedenichia*, which I have not studied, appears related to the *Euschöngastoides* group of genera. Descriptions and illustrations of nymphs of *Schoutedenichia* indicate that they share the features listed above.

Euschöngastoides is separable from *Pseudoschöngastia* by the nature of the sensilla (rather thin and quite flexible in *Euschöngastoides*, thicker and but slightly flexible in *Pseudoschöngastia*) and by the tectal margin (smooth in *Pseudoschöngastia*, with small teeth in *Euschöngastoides*). *Walchia* differs from *Euschöngastoides* in several characters, including the absence of a tectal seta and the possession of a dorsoapical stumplike process on tarsus I in *Walchia*.

Nymphs of *Euschöngastia perameles* (Womersley) and *E. smithi* (Womersley) have been described by Domrow (1955). The descriptions and illustrations indicate that these nymphs will probably key out to *Euschöngastoides*. Possibly, they would fall in *Pseudoschöngastia*. At any rate, it is evident that these species belong in the *Euschöngastoides-Pseudoschöngastia-Walchia* group of genera and not in *Euschöngastia*. These species share with the *Euschöngastoides* group of genera the pertinent characteristics (8), (11), and (17); two species possess precoxal plates and so violate character (2) for *Euschöngastoides* and its relatives. Larvae of *E. perameles* and *E. smithi* have been described by Womersley; scuta of these larvae are similar to those of species of *Euschöngastoides*. I am uncertain as to whether these two species should be accommodated in *Euschöngastoides*, *Pseudoschöngastia*, or a new genus.

The nymph of *Euschöngastia indica* (Hirst) as described by Wharton (1946:159-161) suggests that this species may belong to

Euschöngastoides. Wharton's description is not sufficiently complete to make placement positive.

KEY TO SPECIES OF EUSCHÖNGASTOIDES (NYMPHS)

1. Posterior body setae with tips ending in 2-4 attenuated branches; tectal seta longer (about 12 μ) with more branches . . . . *hoplai* p. 229
2. Posterior body setae with tips rather abruptly pointed and bearing 6 or more very minute branches; tectal seta shorter (about 7 μ) with fewer branches . . . . . *loomisi* p. 230

Euschöngastoides hoplai (Loomis) New Combination

(Figs. 31, 87, 126, 127, 146, 179, 186, 219)

Trombicula (*Euschöngastoides*) *hoplai* Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 294-296 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1305-1306 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color white. Setae rather short, with fine branches tending to project at right angles from stems; tips of posterior setae ending in 2 to 4 short attenuated branches; posterior setae about 35 μ long. Sternum roughly rectangular in shape, rather distinctive, with 4 to 6 setae. Measurements of tarsus I (means of 10 specimens); TL: 86.2 ± 3.095, TH: 50.9 ± 0.924, TL/TH: 1.69 ± 0.0526.

Gnathosoma: Pharynx with reticulate markings covering about half its width. Cheliceral base stout, distinctive in shape, punctate; blade elongated but shearlike, apodeme of blade not constricted and rather narrow; blade with about 9 rather small teeth commonly on distal half. Cheliceral measurements (means of 12 specimens); BL: 52.3 ± 1.534, BH: 25.6 ± 0.4345, CL: 24.8 ± 0.7054, BL/BH: 2.03 ± 0.0467, BL/CL: 2.10 ± 0.0264. Palpus stout, small; accessory claws thin; dorsal tibial setae large; tarsala about 6 μ long; tarsus with 1 inner and 1 outer apical nude setae. Setal counts (means of 7 specimens); femur: 6.93 ± 0.3996, genu: 8.00 ± 0.2182, tibia: 5 (no variation), tarsus: range 6-7.

Scutum: Tectum with about 15-20 small serrations on margin; seta short but small branches rather numerous. Crista very narrow. Sensillary area with ridges weak but visible; no ridges medial to sensillary bases; sensilla flexible; longer branches on distal part of sensilla tend to run at right angles to stems, stems assume zigzag appearances near apex. Scutal measurements (means of 10 specimens): ASL: 52.2 ± 1.769, SB: 42.2 ± 1.872, TS: 12.2 ± 1.278, SENS: about 75, ASL/SB: 1.26 ± 0.0372.

Remarks.—This species is apparently widely distributed in the

central and southwestern United States. Postlarvae probably inhabit the soil surrounding the nests of their mammalian hosts.

Euschöngastoides hoplai proved very difficult to culture. The inactive stages seem unusually susceptible to mold. The nymphs move very sluggishly. Both Collembola eggs and crushed collembolans were offered as food materials, but the nymphs did not eat.

An obvious question concerns the proper identification of the nymphal stages of *E. loomisi* and *E. hoplai.* A field trip was made to Barber County, Kansas, in 1955, with specific objective of obtaining unquestionable evidence of the nymphal identification. In the case of *E. loomisi* this was achieved, by the isolated rearing of a single individual and recovery of the larval skin. Several individuals of *E. hoplai* were found but none reached the nymphal stage. There is, however, strong evidence associating the nymphal form with the larvae of *E. hoplai.* This species was reared by me on two occasions; in both instances larvae similar to those placed in culture were identified as *E. hoplai* when the culture was started. Dead larvae removed from the cultures were *E. hoplai.* No nymphs of this type were reared in mixed cultures, nor were any found as contaminants of other cultures. Also, the association of larva and nymph was observed independently (and preceding my work) by Louis J. Lipovsky. Thus it appears most certain that the nymphs described as *E. hoplai* are correctly identified.

Specimens examined.—Total 12 nymphs, as follows: KANSAS. *Barber County:* 1 mi. W, 4½ mi. S Aetna, *Cynomys ludovicianus,* July 27, 1952 (7 nymphs, reared DAC); 10½ mi. W Hardtner, *Cynomys ludovicianus,* July 26, 1952 (1 nymph, reared DAC); 4 mi. S Aetna, *Neotoma micropus,* August 22, 1949 (4 nymphs, reared LJL).

Euschöngastoides loomisi (Crossley and Lipovsky), New Combination

(Figs. 8, 30, 223)

Euschöngastia loomisi Crossley and Lipovsky, 1954, Proc. Ent. Soc. Washington, vol. 56, pp. 243-246 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1346-1347 (*larva*).

Description of nymph.—Resembles *E. hoplai* except as follows:

Body: About 0.6 mm. long. Setae with tips rather abruptly pointed, with variable number (six or more) very tiny branches; posterior setae about 40 μ long. Measurements of tarsus I (means of 9 specimens); TL: 78.9 ± 1.006, TH: 46.4 ± 0.989, TL/TH: 1.70 ± 0.0236.

Gnathosoma: Cheliceral base with few puncta; blade with apodeme shorter and broader; with about 9 teeth restricted to distal

half of blade. Cheliceral measurements (means of 10 specimens); BL: 51.5 ± 0.6709, BH: 24.2 ± 0.5541, CL: 24.2 ± 0.4899, BL/BH; 2.14 ± 0.0494, BL/CL: 2.14 ± 0.0394. Palpus with tarsala about 5 μ long. Setal counts; femur (8 specimens): 5.63 ± 0.2060, genu (10 specimens): 7.3 ± 0.3267, tibia: range 4-6, tarsus: range 5-6.

Scutum: Tectal seta smaller, with fewer branches. Scutal measurements (means of 8 specimens); ASL: 51.0 ± 1.662, SB: 46.1 ± 1.576, TS: 7.25 ± 0.4532, SENS: about 90, ASL/SB: 1.17 ± 0.0361.

Remarks.—Like *E. hoplai, E. loomisi* nymphs were inactive in culture. They were not observed to feed on the Collembola eggs and crushed collembolans offered to them.

Euschöngastoides loomisi is known from the central and southwestern United States and from northern Mexico. Postlarvae probably inhabit the soil surrounding the nests and burrows of their mammalian hosts.

Specimens examined.—Total 17 nymphs, as follows: KANSAS. *Barber County:* 4 mi. S Aetna, *Neotoma micropus,* July 11, 1955 (1 nymph, reared RBL, idet. by larval skin) and August 22, 1949 (13 nymphs, reared LJL), and *Peromyscus maniculatus,* October 7, 1951 (1 nymph, reared LJL); 3 mi. E, 5 mi. S Aetna, *Neotoma micropus,* July 25, 1952 (1 nymph, reared DAC); 10½ mi. W Hardtner, *Cynomys ludovicianus,* July 26, 1952 (1 nymph, reared DAC).

Genus *Neoschöngastia* Ewing

Neoschöngastia Ewing, 1929, Manual of External Parasites, Springfield, Ill., Thomas, p. 187 (type *Schöngastia americana* Hirst) *(larva);* Wharton and Hardcastle, 1946, Jour. Parasit., vol. 32, p. 288 *(nymph);* Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 84 *(nymph);* Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 388 *(nymph).*

Diagnosis (nymph).—(1) Eyes absent. (2) *Precoxal plates of coxae I present but not fused in midline to form longitudinally divided sternum.* (3) *Body setae with compound branching;* not expanded; *long and short setae intermixed.* (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade narrowed but shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome projecting but blunt at tip;* with about eight short apical nude setae. (9) Pharynx indistinct. (10) Tectum large, hyaline, with teeth; with one tectal seta. (11) *Sensillary area reniform;* mean ratio ASL/SB: about 2.0-2.2. (12) Without branched body seta in sensillary area. (13) Sensilla variable, with branches.

Additional features (nymph).—(14) Body size medium (about 0.6 mm. long), strongly constricted, truncate posteriorly. (15) Precoxal plates of coxae I touching in midline but not fused; sternum open posterior to plates. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral but shortened; base with posterior tip depressed. (18) Palpus unsually stout, broad; usually elongated; claw curved, *extremely elongated in American species; one or two accessory claws;* tarsus with about nine nude or nearly nude setae and one apical nude seta. (19) Hypostome with ten to twenty ventral branched setae. (20) Basis capituli of usual shape. (21) Crista long but not narrowed, rodlike. (22) Sensillary area with basal plate of two rather widely separated halves; bulla much reduced in size; carina absent; sensillary bases rather small, *placed well forward;* ridges present but variable; apodeme much reduced. (23) About ten parascutal setae.

Remarks.—In addition to the nymphs described in the present paper, others have been described. Wharton and Hardcastle (1946: 288) published descriptions of the nymphs of *N. carveri* Wharton and Hardcastle and another species, either *americana solomonis* Wharton and Hardcastle or *monticola* Wharton and Hardcastle. The nymph of *N. gallinarum* (Hatori) has been described by Womersley (1952:390-391). The foregoing diagnosis is in agreement with these published accounts, except as follows: The palpal claws of other than American species are not extremely elongated. No mention is made of the presence or absence of precoxal plates, either by Wharton and Hardcastle or by Womersley. The single nymph of *N. carveri* has two tectal setae and is probably aberrant in this respect.

As larvae, species of *Neoschöngastia* are recognized by the submergence of the scutum beneath the cuticular striae. The larvae otherwise appear similar to many species now placed in *Euschöngastia.*

Although the larvae are placed by this single key character, nymphs are abundantly distinct from those of other genera. It is difficult to suggest to which genera *Neoschöngastia* may be related. The nymphal scutum is distinctive; it is somewhat suggestive of *Cheladonta* but nymphs of these two genera seem specialized along different lines and certainly do not share many other features. Of the characters listed above, the elongated palpal claws are the most ready means of identification for the American forms. Otherwise,

the body setae are distinctive in being compoundly branched long and short setae being intermixed.

Womersley (1952:389) gives an adequate key to the known nymphs of *Neoschöngastia.* American species are easily separated from these by their very elongated palpal claws. The two American species are themselves separated in the following key.

KEY TO AMERICAN SPECIES OF NEOSCHÖNGASTIA (NYMPHS)

1. Cheliceral blade without teeth; palpal tibia with two accessory claws; sensilla not expanded in midregions, flexible, with long branches restricted to distal third . . . . . *brennani* p. 234
2. Cheliceral blade with teeth; palpal tibia with one accessory claw; sensilla somewhat expanded in midregion, with numerous spinelike branches not restricted to distal third . . . . . *americana* p. 233

Neoschöngastia americana (Hirst)

(Figs. 40, 71, 177, 180, 193, 194, 201, 222, 224)

Schöngastia americana Hirst, 1921, Ann. and Mag. Nat. Hist., vol. 17, p. 37 (*larva*).

Neoschöngastia americana, Ewing, 1929, Manual of External Parasites, Springfield, Ill., Thomas, p. 187 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1354-1355 (*larva*).

Description of nymph.—Body: About 0.6 mm. long, color red. Setae with thick stems and short thick branches which in turn divide into 2-4 fine branches; tips of posterior setae with 2-3 shorter compound branches; longer body setae about four times as long as shorter ones; long posterior setae about 70 μ long. Sternum with rounded precoxal plates of coxae I meeting at midline, each plate bearing 2-4 setae; sternal area open behind. Legs appear shortened. Measurements of tarsus I (means of 10 specimens); TL: 95.4 ± 0.9214, TH: 49.0 ± 0.5164, TL/TH: 1.94 ± 0.0305.

Gnathosoma: Hypostome with about 8 short apical nude setae. Cheliceral base normal, punctate; blade narrowed, elongated but shearlike, with about 10 teeth. Cheliceral measurements (means of 10 specimens); BL: 71.6 ± 1.845, BH: 28.7 ± 0.7000, CL: 30.6 ± 0.5927, BL/BH: 2.51 ± 0.0781, BL/CL: 2.36± 0.0851. Palpus with claw very elongated, dorsal tibial seta heavy; lower accessory claw absent, apparently replaced by branched body seta; upper accessory claw normal; tarsala about 8 μ long; most tarsal setae nude, rather thick; tarsus with apical nude seta elongated, on outer surface. Setal counts; femur (8 specimens): 3.38 ± 0.1813, genu (9 specimens): 7.83 ± 0.2041, tibia: range 3-5, tarsus, range 7-9.

Scutum: Tectum nearly square. Sensillary area with basal plate rather distinctive; ridges weak but obvious, lending reniform ap-

pearance to area; bulla small and square; sensilla thick, somewhat expanded in midregions, with numerous spinelike branches. Scutal measurements (means of 9 specimens); ASL: 62.3 ± 0.6872, SB: 28.7 ± 2.0178, TS: 44.1 ± 1.2427, SENS: about 90, ASL/SB: 2.17 ± 0.0532.

Remarks.—Neoschöngastia americana appears to be a widespread species in the southeastern United States and in other areas. Most of the hosts of this species are birds; however, Loomis (1956:1355) shows that cottontails are a very important host animal. Loomis also presents evidence to show that the postlarvae probably inhabit soils which are well drained, warm to hot and dry.

Larvae of *N. americana* and *N. brennani* are quite similar, but nymphs of these species differ in several characters, as indicated in the key. Differences between the two species were first observed in the nymphal stage by L. J. Lipovsky. Wharton and Hardcastle (1946:313) describe a nymph which is either that of *N. americana solomonis* or of *N. monticola.* There are numerous differences between their description and the nymph of *N. americana.* Probably the nymph pertains to *N. monticola;* if it is indeed the nymph of *N. a. solomonis,* then *solomonis* should be considered a distinct species.

Neoschöngastia americana proved very difficult to culture. Moderate success was achieved in culture tubes which were allowed to remain much drier than usual. The nymphs ate active stages of collembolans, but ignored their eggs.

Specimens examined.—Total 38 nymphs, as follows: KANSAS. *Douglas County:* Lawrence, *Sylvilagus floridanus,* July 11, 1949 (10 nymphs, reared LJL), and *Colinus virginianus,* September 15, 1952 (10 nymphs, reared RBL-DAC); 4 mi. S Lawrence, *Sylvilagus floridanus,* July 25, 1948 (2 nymphs, reared LJL); 5 mi. S Lawrence, *Sylvilagus floridanus,* July 14, 1948 (16 nymphs, reared LJL).

Neoschöngastia brennani Crossley and Loomis

(Figs. 11, 41, 72, 100, 101, 149)

Neoschöngastia brennani Crossley and Loomis, 1955, Ent. News, vol. 66, pp. 114-117 *(larva).*

Description of nymph.—Resembles *N. americana* except as follows:

Body: About 0.6 mm. long. Setae with somewhat longer branches; posterior setae about 70 μ long. Precoxal plates with each plate bearing about 8 setae. Measurements of tarsus I (means of

2 specimens); TL: 91.5 ± 3.50, TH: 44.5 ± 0.50, TL/TH: 2.05 ± 0.050.

Gnathosoma: Hypostome with about 8 very short apical nude setae. Cheliceral blade without teeth. Cheliceral measurments (means of 2 specimens); BL: 94.5 ± 0.50, BH: 34.5 ± 2.50, CL: 36.5 ± 1.50, BL/BH: 2.8 ± 0.250, BL/CL: 2.6 ± 0.140. Palpus with lower accessory claw present but small; tarsala about 7 μ long. Setal counts (means of 2 specimens); femur: 3.5 ± 0.000, genu: 10.25 ± 1.2502, tibia: 3 (all on outer surface), tarsus: range 8-9.

Scutum: Sensilla thick, not expanded in midregions, flexible; with long branches restricted to distal thirds. Scutal measurements (means of 2 specimens); ASL: 66.0 ± 8.000, SB: 34.0 ± 3.00, TS: 38.0 ± 0.00, SENS: about 115, ASL/SB: 1.95 ± 0.500.

Remarks.—Loomis (1956:1359) notes that this species is known only from birds, particularly the woodpecker, *Melanerpes erythrocephalus,* and suggests that postlarvae may inhabit standing or fallen dead trees.

Specimens examined.—Total 2 nymphs, as follows: KANSAS. *Barber County:* 10½ mi. W Hardtner, *Melanerpes erythrocephalus,* July 26, 1952 (2 nymphs, reared DAC).

Genus *Pseudoschöngastia* Lipovsky

Pseudoschöngastia Lipovsky, 1951, Jour. Kansas Ent. Soc., vol. 24, p. 95 (type *Pseudoschöngastia hungerfordi* Lipovsky) *(larva).*

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates absent. (3) Body setae branched, not expanded, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome short, blunt; with about twenty short apical nude or nearly nude setae.* (9) *Pharynx marked with a reticulate pattern.* (10) Tectum broad, hyaline, *with smooth margin;* with one small tectal seta. (11) *Sensillary area wide,* mean ratio ASL/SB: about 1.7. (12) Without branched body seta in sensillary area. (13) Sensilla straight, rather thick to subclavate, with branches.

Additional features (nymph).—(14) Body medium in size (about 0.6 mm. long), elongated. (15) Sternum broadly pentagonal, closed behind. (16) Tarsus I elongated. (17) *Articulating area of cheliceral base with basis capituli posterior; base with posterior tip depressed.* (18) Palpus stout, small; distal portion of tibia not

unusually elongated; claw slightly curved, moderate in size; two accessory claws; tarsus with four to seven branched setae and *two apical nude setae.* (19) Hypostome with about ten ventral branched setae. (20) Basis capituli short, broad. (21) Crista short, narrow. (22) Sensillary area with basal plate of two well-separated halves; bulla rather large; carina absent; sensillary bases placed well laterally; anterior, lateral, and posterior ridges weak; ridges medial to sensillary bases absent; apodeme apparently absent. (23) About ten parascutal setae.

Remarks.—Pseudoschöngastia is separable from, but closely related to, *Euschöngastoides.* Also, its relationship to *Walchia* and to *Schoutedenichia* is evidenced by several characters. Audy (1954: 155) suggests that *Pseudoschöngastia* is really related to *Euschöngastia,* an opinion which I do not share. However, Audy may be considering as typical *Euschöngastia* certain species which would better be accommodated in *Euschöngastoides.*

Larvae of *Pseudoschöngastia* are recognized by the posterolateral scutal setae being displaced from the scutum and the legs II and III having their femurs undivided. Otherwise, they also show similarities to larvae of *Euschöngastoides.*

In culture, both species of *Pseudoschöngastia* eat active stages of collembolans rather than their eggs.

KEY TO SPECIES OF PSEUDOSCHÖNGASTIA (NYMPHS)

1. Reticulate markings cover about half the width of the pharynx; cheliceral blade with about 6 large conspicuous teeth; sensilla straight, never expanded ..... *farneri* p. 237
1'. Reticulate markings restricted to midline of pharynx; cheliceral blade with about 10 small teeth; sensilla straight, usually somewhat expanded but occasionally not ..... *hungerfordi* p. 236

Pseudoschöngastia hungerfordi Lipovsky

(Figs. 32, 91, 144, 218)

Pseudoschöngastia hungerfordi Lipovsky, 1951, Jour. Kansas Ent. Soc., vol. 24, pp. 95-99 *(larva).*

Description of nymph.—Body: About 0.6 mm. long, color white. Setae short, with long branches; tips of posterior setae composed of 2-3 rather long branches; posterior setae about 20 μ long. Sternum closed behind, roughly pentagonal, with about 8 setae. Measurements of tarsus I (means of 9 specimens); TL: 88.1 ± 2.300, TH: 52.1 ± 1.263, TL/TH: 1.70 ± 0.0373.

Gnathosoma: Reticulate markings on pharynx restricted to midline. Cheliceral base stout, puncta apparently absent; blade shearlike, with about 10 small teeth covering most of dorsal margin;

occasional specimens with fewer (about 8) larger teeth. Cheliceral measurements (means of 8 specimens); BL: 44.5 ± 2.535, BH: 23.3 ± 0.974, CL: 26.6 ± 0.681, BL/BH: 2.01 ± 0.106, BL/CL: 1.76 ± 0.0906. Palpus stout, small, accessory claws thin; tarsala about 7 μ long; tarsus with one inner and one outer apical nude seta. Setal counts (means of 8 specimens); femur: 3.00 ± 0.125, genu: 4.10 ± 0.164, tibia: range 2-3, tarsus: range 4-6.

Scutum: Tectal seta small and with few branches (about 4). Sensillary area with bulla triangular; sensilla stiff, usually somewhat expanded and nearly subclavate, rarely unexpanded, with short branches on basal thirds, long straight thick-based branches on midregions, and shorter but similar branches on apical thirds. Scutal measurements (means of 10 specimens); ASL: 55.3 ± 0.9781, SB: 32.3 ± 0.6047, TS: 6.75 ± 0.250, SENS: about 80, ASL/SB: 1.69 ± 0.0378.

Remarks.—The characters in the key separate most specimens of *P. hungerfordi* from *P. farneri.* Several poorly mounted specimens could not be placed satisfactorily in one species or the other.

Pseudoschöngastia hungerfordi was readily cultured, and a number of adults were so obtained.

Specimens examined.—Total 149 nymphs, as follows: KANSAS. *Barber County*: 3 mi. S Aetna, *Neotoma micropus,* July 25, 1952 (5 nymphs, reared DAC); 4 mi. S Aetna, *Neotoma micropus,* July 11, 1955 (7 nymphs, reared DAC, idet. by larval skins), and August 22, 1949 (46 nymphs, reared LJL); 5 mi. S, 3 mi. E Aetna, *Neotoma micropus,* July 25, 1952 (2 nymphs, reared DAC). *Douglas County:* 5 mi. S Lawrence, *Sylvilagus floridanus,* July 14, 1948 (10 nymphs, reared LJL). *Greenwood County:* 1½ mi. E Hamilton, *Neotoma floridana,* August 14, 1949 (46 nymphs, reared LJL). *Rawlins County:* 9 mi. W Atwood, *Reithrodontomys megalotis,* August 10, 1949 (2 nymphs, reared LJL). TEXAS. *Bexar County:* Camp Bullis, *Sylvilagus auduboni,* April 25, 1954 (31 nymphs, reared RBL-DAC).

Pseudoschöngastia farneri Lipovsky

(Figs. 33, 90, 124, 125, 145)

Pseudoschöngastia farneri Lipovsky, 1951, Jour. Kansas Ent. Soc., vol. 24, pp. 101-102 *(larva).*

Description of nymph.—Resembles *P. hungerfordi* except as follows:

Body: Measurements of tarsus I (means of 9 specimens); TL: 90.0 ± 2.06, TH: 48.9 ± 1.07, TL/TH: 1.88 ± 0.0325.

Gnathosoma: Reticulate markings covering about half the width of the pharynx. Cheliceral blade with about 6 larger conspicuous teeth; sometimes with more (about 8) teeth. Cheliceral measurements (means of 9 specimens); BL: 55.8 ± 0.7412, BH: 29.4 ± 0.7287, CL: 29.9 ± 0.5880, BL/BH: 1.91 ± 0.2609, BL/CL: 1.88 ± 0.2146. Setal counts of palpus (means of 9 specimens); femur: 2.89 ± 0.139, genu: 6.17 ± 0.238, tibia: range 3-4, tarsus: range 4-7.

Scutum: Sensilla like those of *P. hungerfordi* but never expanded. Scutal measurements (means of 9 specimens); ASL: 54.3 ± 1.10, SB: 32.7 ± 1.146, TS: 6.25 ± 0.500, SENS: about 70, ASL/SB: 1.69 ± 0.0696.

Remarks.—Unlike *P. hungerfordi, P. farneri* was very difficult to maintain in culture. This suggests that *P. farneri* has different requirements, which were not met in the cultures. Loomis (1956: 1350) suggests, however, that these two species are probably often in direct competition as postlarvae, since they frequently occur on the same host and have about the same range of host species.

Specimens examined.—Total 13 nymphs, as follows: KANSAS. *Barber County:* 3 mi. S Aetna, *Neotoma micropus,* July 25, 1952 (2 nymphs, reared DAC); 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus,* April 11, 1949 (1 nymph, reared LJL); 4 mi. S Aetna, *Neotoma micropus,* July 11, 1955 (4 nymphs, reared DAC, idet. by larval skins). *Lyon County:* 2 mi. S Chalk, *Perognathus hispidus,* May 31, 1950 (1 nymph, reared LJL). *Russell County:* 9 mi. S Russell, *Peromyscus maniculatus,* April 26, 1952 (4 nymphs, reared DAC); 5 mi. N, 2 mi. E Graham, *Peromyscus maniculatus,* April 27, 1952 (1 nymph, reared DAC).

Genus *Speleocola* Lipovsky

Speleocola Lipovsky, 1952, Jour. Kansas Ent. Soc., vol. 25, p. 134 (type *Speleocola tadaridae* Lipovsky) (*larva*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 147 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1326 (*larva*).

Diagnosis (nymph).—(1) Eyes absent. (2) Precoxal plates of coxa I absent. (3) Body setae short, not expanded; *with compound branching;* adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) *Cheliceral base unusually elongated* (ratio BL/BH: about 3.5); blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting, with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum small, hyaline, margin

with teeth; with one tectal seta. (11) Sensillary area triangular; ratio ASL/SB: about 2.5. (12) Without branched body seta in sensillary area. (13) Sensilla subclavate; branches short with heavy bases.

Additional features (nymph).—(14) Body small (about 0.4 mm. long). (15) Sternum not closed behind, somewhat elongated. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral; posterior tip of cheliceral base depressed. (18) Palpus somewhat elongated, size small; distal portion of tibia not unusually elongated; claw slightly curved, somewhat elongated; two accessory claws; tarsus with about nine nude or nearly nude setae and three apical nude setae. (19) Hypostome with about ten ventral branched setae. (20) *Basis capituli elongated.* (21) Crista a narrow rod. (22) Sensillary area with basal plate of two halves; bulla reduced in size; carina present; sensillary bases placed well lateral; anterior and lateral ridges strong but posterior ridge weak; *ridges medial to sensillary bases bearing small carinae;* apodeme normal. (23) About eight parascutal setae.

Remarks.—Speleocola is monotypic for S. *tadaridae.* As a larva this species has a peculiar scutum and particularly peculiar sensilla. The sensilla are apparently unexpanded but the branches are broad based and leaflike, possibly producing the effect of an expanded sensillum.

The nymphs of S. *tadaridae* are quite similar to those of *Trombicula* species. The outstanding differences are the compound branching of the body setae and the carinate ridges medial to the sensillary bases. Whether or not these differences are sufficient to merit the generic distinction is a debatable question.

Speleocola tadaridae Lipovsky

(Figs. 39, 86, 128, 129, 173, 233)

Speleocola tadaridae Lipovsky, 1952, Jour. Kansas Ent. Soc., vol. 25, pp. 134-137 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1326-1327 (*larva*).

Description of nymph.—Body: About 0.4 mm. long, color not known. Setae short, with few branches further dissected into 2-4 compound branches; posterior setae about 12 μ long. Sternum with about 4 setae. Measurements of tarsus I (means of 10 specimens); TL: 63.8 ± 0.442, TH: 28.4 ± 0.371, TL/TH: 2.25 ± 0.0428.

Gnathosoma: Cheliceral base slightly curved, elongated, area of articulation covering about two-thirds of ventral margin, base punctate; blade shearlike, rather elongated, with about 16 tiny

teeth. Cheliceral measurements (means of 10 specimens) BL: 91.7 ± 0.8172, BH: 26.6 ± 0.6531, CL: 37.4 ± 0.5413, BL/BH: 3.46 ± 0.0670, BL/CL: 2.45 ± 0.0268. Palpus small, with reduced setation, and setae with reduced branching; dorsal setae of genu and tibia nude or nearly so; tibial seta at inner tarsal articulation nude; claw and accessory claws slender; tarsala about 4 μ long; tarsus with 2 inner, 1 outer apical nude setae. Setal counts (means of 10 specimens); femur: 3.45 ± 0.279, genu: 3.25 ± 0.1535, tibia: range 4-5, tarsus: range 7-9.

Scutum: Tectum rather rounded; marginal teeth conspicuous; seta near end of crista. Sensillary area with basal plate rather small; apodeme present, normal, hard to see; bulla triangular and small; carina thin; "saddle" portion of area large, punctate; sensilla expanded, with numerous short spinelike branches. Scutal measurements (means of 10 specimens); ASL: 54.9 ± 0.8175, SB: 22.4 ± 0.4521, TS: 14.4 ± 0.1633, SENS: about 55, ASL/SB: 2.45 ± 0.0342.

Remarks.—This species was reared on a single occasion by L. J. Lipovsky. The nymphs did not eat, and none reached the adult stage.

Specimens examined.—Total 23 nymphs, as follows: OKLAHOMA. *Woods County:* 6 mi. S, 2 mi. W Aetna, Kans., *Tadarida mexicana,* August 24, 1949 (23 nymphs, reared LJL).

Genus *Trombicula* Berlese

Trombicula Berlese, 1905, Redia, vol. 2, p. 155 (type *Trombicula minor* Berlese) (*adult*); Womersley and Heaslip, 1943, Trans. Roy. Soc. South Australia, vol. 67, p. 73 (*part*) (*adult*); Ewing, 1949, Jour. Washington Acad. Sci., vol. 39, p. 235 (*adult*); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 326 (*adult*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 137 (*adult*).

Diagnosis (nymph).—(1) Eyes absent *or 1/1 and adjacent to sensillary area.* (2) Precoxal plates of coxae I absent *or fused in midline to form longitudinally divided sternum.* (3) Body setae variable, branched, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) Tarsus I without dorsoapical stumplike process. (6) Cheliceral base rarely unusually elongated (mean ratio BL/BH: up to 3.6); blade shearlike. (7) Palpal trochanter not elongated. (8) Hypostome pointed, projecting; with about eight apical nude setae. (9) Pharynx indistinct. (10) Tectum square to triangular, hyaline, *margin with teeth;* with one tectal seta. (11) *Sensillary area* triangular;

mean ratio ASL/SB: about 2.0-2.7. (12) Without branched body seta in sensillary area. (13) Sensilla variable, flagelliform to subclavate, with at least basal branches.

Additional features (nymph).—(14) Body small to large (about 0.5-1.0 mm. long), sometimes elongated. (15) Sternum nearly rectangular when longitudinally divided; otherwise open or closed behind and elongated to roughly pentagonal. (16) Tarsus I elongated. (17) Articulating area of cheliceral base with basis capituli ventral; posterior tip of cheliceral base depressed. (18) Palpus stout to somewhat elongated; distal portion of tibia not unusually elongated; two accessory claws; tarsus with about nine branched setae and three to six apical nude setae. (19) Hypostome with about ten to twenty ventral branched setae. (20) Shape of basis capituli variable. (21) Crista a narrow to very narrow rod. (22) Sensillary area with basal plate of two halves, variable; bulla usually large, sometimes reduced; carina present or absent; sensillary bases placed well lateral; anterior, lateral, and posterior ridges present but variable; often additional ridges present; apodeme present, well developed to reduced. (23) About eight to thirty parascutal setae.

Remarks.—In addition to the species described in the present paper, postlarvae of about sixty species of *Trombicula* have been previously described; these are discussed under the appropriate subgenera. Most of the descriptions are inadequate but to my knowledge none will be excluded from the genus by my diagnosis. It should be noted, however, that the foregoing diagnosis is very broad. Many previously described forms are known only as adults; their placement is questionable. I feel that they should be left in *Trombicula* until they can be definitely placed.

The type of the genus, *Trombicula minor* Berlese, is known from the original description of Berlese and a redescription of several years later; Willmann in 1941 redescribed the types which were subsequently destroyed by war. The type locality is a rather inaccessible bat cave in Java; it has not been possible to collect topotypical material. This mite has been the subject of much discussion which I will not attempt to summarize; this has been done by Womersley (1952:328-330) and by Audy (1954:138-140). I shall attempt to list what definite information we do have concerning *T. minor.* (1) The types were adults (as shown by Willmann) and almost certainly trombiculids. (2) The adults were small, even for trombiculids. (3) The presence of these mites

in bat caves strongly suggests that the larvae are parasites of bats, but this is not certain. (4) In the way of descriptive material we have the brief descriptions of Berlese and of Willmann, and illustrations of scuta and palpi by these authors. (5) It seems safe to assume that if *T. minor* possesses any strikingly unsual features these would have been detected by either Berlese or Willmann.

The descriptions are quite brief. The illustrations of palpi are difficult to evaluate; the palpi were drawn in a half-turned position and it seems to me that they could represent almost any trombiculid. The illustrations of the scutum by Berlese are poor; the illustration by Willmann is better but is obviously diagrammatic. Authors have been unable to agree as to whether Willmann's drawing of the sensillary area showed enlarged sensillary bases or eyes adjacent to the scutum (Willmann himself was uncertain on this point). While Willmann's illustration appears to me to show a *Trombicula* or *Euschöngastia* sensillary area, I believe that with a slight stretch of the imagination it could be fitted to several other genera.

From these considerations I draw the following conclusions. (1) It is almost a certainty that *T. minor* is a small trombiculid. (2) It is highly probable that the larvae are parasites of bats. (3) It is possible that *T. minor* is a member of the genus *Trombicula* as currently understood, but it could easily be considered congeneric with species now placed in different genera. (4) It will be impossible to recognize *T. minor* on the basis of the existing descriptions.

As type of the genus *Trombicula, T. minor* is bound to continue to cause taxonomic indecision and confusion. One acceptable solution would be to restrict *Trombicula* to *T. minor* and remove all other species to a different genus (or genera). Concerning this course, Wharton and Fuller (1951:42) write, "Such a course would be entirely unjustified, since, despite the plethora of generic names that have been proposed, *Trombicula* as understood here is no broader in its content than are such genera as *Neoschöngastia* and *Euschöngastia*. In handling nomenclatorial problems of this kind stability should be maintained if it is at all possible to do so and still remain in agreement with the known biological facts." This conservative course has so far been more productive than the alternative would be. However, the genus *Trombicula* has become unwieldly, not through the number of species it contains but through their diversity. At present the revision of this genus would constitute a very difficult task, and as more species which key out to *Trombicula* are added, the difficulties will increase. It seems to

me that the best course would be to appeal to the International Commission of Zoological Nomenclature to use its plenary powers to stabilize the genus *Trombicula,* by replacement of the type *T. minor* with some well-known species. I would suggest that the species selected be a bat parasite in the Asiatic-Pacific area.

The genus *Trombicula* has been divided into several subgenera; there are more or less distinct groups of species which have been left in *Trombicula* primarily because they are possibly congeneric with *T. minor.* Included in this paper are representatives of *Eutrombicula, Neotrombicula,* and *Leptotrombidium,* plus species which fall into no well defined subgenus and are therefore customarily placed in the subgenus *Trombicula.* These subgenera will be discussed further under their headings.

As a genus, *Trombicula* as understood here is close to the genera *Speleocola, Blankaartia,* and *Euschöngastia. Speleocola* (monotypic) may well be an aberrant *Trombicula. Blankaartia* has primitive characteristics but is nevertheless similar to some species of *Trombicula. Euschöngastia* is separable from *Trombicula* in both larval and postlarval stages on single characters; *Trombicula* larvae have unexpanded sensilla and nymphs have teeth on the tectal margin, while *Euschöngastia* larvae have expanded sensilla and have a smooth tectal margin. Otherwise the genera have some species which appear similar and it may become increasingly difficult to separate these two genera as they are currently understood.

KEY TO SPECIES OF TROMBICULA (NYMPHS)

1. Eyes present adjacent to sensillary area; posterior scutal ridge with two strong elevations medial to sensillary bases (subgenus *Eutrombicula*) 2
1′. Eyes absent; posterior scutal ridge without elevations or with only very weak elevations 5
2. Posterior body setae with tips rounded, slightly expanded, bearing many short branches . . . . . *belkini* p. 248
2′ Posterior body setae tapering gradually, ending in 2-3 short branches 3
3. Smaller; mean ASL about 90 μ, individual ASL less than 100 μ *alfreddugèsi* p. 245
3′. Larger; mean ASL about 115 μ or more, individual ASL more than 100 μ 4
4. Posterior body setae mostly ending in two tiny branches, but some ending in three . . . . . *lipovskyana* p. 249
4′. Posterior body setae mostly ending in three tiny branches, but some ending in two . . . . . *splendens* p. 250
5. Precoxal plates of coxae I present and fused medially to form a longitudinally divided sternum (Subgenus *Leptotrombidium*) *myotis* p. 257

5'. Precoxal plates of coxae I absent 6
6. Palpal tarsus with three apical nude setae (subgenus *Trombicula*, part) 7
6'. Palpal tarsus with more than three apical nude setae 10
7. Cheliceral base unusually elongated (mean ratio BL/BH: 3.6) *ornata* p. 267
7'. Cheliceral base not unusually elongated (mean ratio BL/BH: less than 3.0) 8
8. Posterior body setae shorter, about 15 μ long ..... *merrihewi* p. 264
8'. Posterior body setae longer, about 20-25 μ 9
9. Smaller species; ASL about 59 μ ..... *crossleyi* p. 258
9'. Larger species; ASL about 66 μ ..... *trisetica* p. 268
10. Palpal tarsus with four apical nude setae ..... (*T.*) *montanensis* p. 265
10'. Palpal tarsus with five or six apical nude setae 11
11. Sensilla nude except for short basal branches; rarely furcate at tips ..... (*N.*) *whartoni* p. 255
11'. Sensilla with at least several distal branches in addition to small basal branches 12
12. Sensilla flagelliform, very flexible, scarcely thicker than branches; branches long ..... (subgenus *Trombicula*, part) 13
12' Sensilla flexible but thickened, much thicker than branches; branches usually shorter 14
13. Cheliceral base unusually elongated (BL/BH: 3.0) ..... *kansasensis* p. 262
13'. Cheliceral base not unusually elongated (mean ratio BL/BH: 2.6) ..... *gurneyi* p. 261
14. Apical third of posterior body seta with many very short branches; longer branches mostly restricted to basal portion (subgenus *Trombicula*, part) 15
14'. Posterior body seta normal, not so modified (subgenus *Neotrombicula*, part) 16
15. Occasional long branches on apical third of posterior body seta ..... *kardosi* p. 263
15'. Longer branches entirely restricted to basal portion of posterior body seta ..... *fitchi* p. 260
16. Smaller species; mean ASL about 65 μ ..... *sylvilagi* p. 254
16'. Larger species; mean ASL about 84.97 μ 17
17. Posterior body setae longer (about 70 μ) ..... *autumnalis* p. 252
17'. Posterior body setae shorter (about 45 μ) ..... *lipovskyi* p. 253

Subgenus *Eutrombicula* Ewing

Eutrombicula Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 293 (type *Microtrombidium alfreddugèsi* Oudemans) (*larva*).
Trombicula (*Eutrombicula*), Jenkins, 1949, Ann. Ent. Soc. America, vol. 42, pp. 289-317 (*postlarvae*).

Diagnosis (*nymph*).—(1) Eyes 1/1, adjacent to sensillary area. (10) Tectum square, with numerous small teeth on margin. (22) Sensillary area with posterior scutal ridge with two strong elevations medial to sensillary bases. (23) About twenty to thirty parascutal setae.

Remarks.—This subgenus could easily be raised to generic rank. I have not done so, for two reasons: One, despite differences. *Eutrombicula* species are very close to some other species of *Trombicula* (for example, *T. gurneyi*); and two, species in the Asiatic-Pacific area require re-examination (see Audy 1954:146). Of the subgeneric characters the presence of eyes adjacent to the sensillary area is probably the most important. However, it should be pointed out that the eyes of *T. belkini* were seen on but one specimen. Also, *T. frittsi* Wharton appears to have eyes in this position (nymph described by Womersley, 1952, p. 330) but otherwise does not seem to be a *Eutrombicula*. Nevertheless, I am inclined to look upon any nymph with eyes in this position as very probably being a member of this subgenus. In culture, nymphs readily ate Collembola eggs. Adults were obtained of all four species cultured.

Other postlarvae of *Eutrombicula* have been described. The species *T. coarctata* Berlese, *T. manriquei* Ewing, and *T. mediocris* Berlese are known as adults only. Nymphs of *T. hirsti* Sambon and *T. sarcina* Womersley have been described. Both nymphs and adults of *T. batatas* (Linnaeus), *T. samboni* Womersley, and *T. wichmanni* (Oudemans) have been described. I have not been able to construct a key to handle these forms; the included key contains only the species I have actually examined. Womersley (1952:325) considers Willmann's drawing of *T. minor* to exhibit eyes; therefore he considers *Eutrombicula* a synonym of *Trombicula* (*Trombicula*). While this is possible, I prefer to follow the interpretation of Ewing and others that the illustration shows enlarged sensillary bases rather than eyes.

Trombicula alfreddugèsi (Oudemans)

(Figs. 21, 74, 110, 111, 168, 191, 226, 227)

Microthrombidium alfreddugèsi (Oudemans), 1910, Ent. Berichten, vol. 3, p. 84 (*larva*).

Eutrombicula alfreddugèsi, Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 294 (*larva*).

Trombicula (Eutrombicula) alfreddugèsi, Jenkins, 1949, Ann. Ent. Soc. America, vol. 42, p. 306 *(adult);* Wolfenbarger, 1953, Ann. Ent. Soc. America, vol. 45, pp. 652-654 *(postlarvae).*

Trombicula (Trombicula) alfreddugèsi, Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 333.

Trombicula irritans, Ewing, 1929, Manual of External Parasites, p. 23 *(adult).*

Trombicula cinnabaris Ewing, 1921, Ann. Ent. Soc. America, vol. 13, p. 387 *(adult).*

Eutrombicula vanommereni, Michener, 1946, Ann. Ent. Soc. America, vol. 39, p. 414 *(postlarvae);* Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 332.

Description of nymph.—Body: About 0.9 mm. long engorged, rather rounded posteriorly, color orange to red. Eyes rounded,

red, closely adjacent to sensillary area, about 17 μ in diameter. Setae long, stems thick but tapered, with many fine branches; tips of posterior body setae with 2, rarely 3, short branches; posterior setae about 60 μ long. Sternum closed behind, roughly pentagonal in shape, with about 8 setae. Measurements of tarsus I (means of 20 specimens); TL: 120.0 ± 2.028, TH: 65.1 ± 0.8032, TL/TH: 1.85 ± 0.0246.

Gnathosoma: Chelicerae of usual facies; base punctate; blade with about 20 teeth of various sizes. Cheliceral measurements (means of 16 specimens); BL: 107.2 ± 2.049, BH: 46.6 ± 0.8803, CL: 61.9 ± 1.3735, BL/BH: 2.28± 0.0393, BL/CL: 1.68 ± 0.0542. Palpus of usual shape, except femur unusually stout; tarsala about 12 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 9 specimens); femur: 5:61 ± 0.2324, genu: 10.56 ± 0.3783, tibia: range 4-5, tarsus: range 9-10.

Scutum: Tectum about square, margin with about 20 small teeth. Sensillary area with basal plate of two widely separated bands; apodeme conspicuous; ridges strong; ridges medial to sensillary bases elevated and joining posterior margin to give posterior portion of sensillary area a "bilobed" appearance; bulla triangular, punctate, rather prominent; carina usually doubled, rather thick, prominent; sensilla flagelliform, elongate, with short basal branches and long attenuate distal branches; distal portions unipectinate. Parascutal setae numerous, about 20-30. Scutal measurements (means of 21 specimens); ASL: 88.1 ± 1.273, SB: 34.3 ± 0.4660, TS: 34.5 ± 0.5986, SENS: about 130, ASL/SB: 2.58 ± 0.0318.

Remarks.—The synonomy given is far from complete, but the important postlarval descriptions are included.

Trombicula alfreddugèsi has been the object of some concentrated studies. Most recently, Loomis (1956:1259-1280) presented evidence on the factors influencing the abundance of larval *T. alfreddugèsi* on hosts. Some discussion was devoted to the postlarval habitat. Evidently postlarvae normally inhabit grassy soil, particularly in the more open areas. Although most trombiculids have not been collected as postlarvae, nymphs and adults of *T. alfreddugèsi* are frequently found beneath limestone rocks and in soil samples during the spring and early summer. Apparently they overwinter as postlarvae.

This species is not strikingly distinct from the two other species of *Trombicula (Eutrombicula)* found in eastern Kansas. However, by characters related to their smaller size, nymphs of *T. alfred-*

dugèsi are more readily separable from *T. lipovskyana* and *T. splendens* than those two species are separable from each other.

Trombicula alfreddugèsi is a very common parasite upon many species of both birds and mammals, and is found throughout most of the United States. Among the nymphs available for study, specimens from western Kansas and northern Texas were significantly smaller in the measurement ASL than specimens from eastern Kansas. No other differences were noted between specimens from these areas.

Specimens examined.—Total 159 nymphs, as follows: KANSAS. *Anderson County:* 3 mi. N Garnett, *Crotaphytus collaris,* July 8, 1948 (7 nymphs, reared LJL). *Barber County:* 4 mi. S Aetna, *Neotoma micropus,* August 22, 1949 (39 nymphs, reared LJL), July 25, 1952 (2 nymphs, reared DAC), and July 11, 1955 (15 nymphs, reared DAC, idet. by larval skins), and *Sylvilagus floridanus,* September 14, 1953 (7 nymphs, reared DAC); 5 mi. S Sun City, *Neotoma micropus,* September 14, 1948 (2 nymphs, reared LJL); 3 mi. S Aetna, *Neotoma micropus,* July 25, 1952 (2 nymphs, reared DAC); 10½ mi. W Hardtner, *Sylvilagus floridanus,* July 25, 1952 (2 nymphs, reared DAC). *Cheyenne County:* 3 mi. N St. Francis, *Perognathus hispidus,* July 23, 1948 (1 nymph, reared LJL), *Pituophis catenifer,* July 22, 1948 (1 nymph, reared LJL). *Douglas County:* Univ. Kansas Natural History Reservation, *Elaphe obsoleta,* August 10, 1953 (12 nymphs, reared DAC, idet. by larval skins), *Crotaphytus collaris,* June 24, 1950 (6 nymphs, reared LJL),—"soil sample," February 27, 1951 (1 nymph, col. RBL); 3 mi. S, 1 mi. E Lawrence, *Sylvilagus floridanus,* July 14, 1949 (1 nymph, reared LJL); 5 mi. S Lawrence, *Sylvilagus floridanus,* July 14, 1949 (7 nymphs, reared LJL); 4 mi. S Lawrence, *Zenaidura macroura,* July 25, 1948 (1 nymph, reared LJL) and *Colinus virginianus,* July 25, 1948 (4 nymphs, reared LJL); 2 mi. W Lawrence, *Sylvilagus floridanus,* June 19, 1949 (9 nymphs, reared LJL). *Miami County:* Miami Co. State Park, *Agkistrodon contortrix,* October 12, 1948 (1 nymph, reared LJL). *Rawlins County:* 8 mi. S Beardsley, *Perognathus hispidus,* July 29, 1948 (1 nymph, reared LJL), and *Cnemidophorus sexlineatus,* July 29, 1948 (1 nymph, reared LJL). *Seward County:* Liberal, *Dipodomys ordii,* September 8, 1948 (1 nymph, reared LJL); 4 mi. NE Liberal, *Sigmodon hispidus,* September 12, 1948 (24 nymphs, reared LJL); 12 mi. NE Liberal, *Sceloporus undulatus,* September 9, 1948 (1 nymph, reared LJL). *Shawnee County:* 3 mi. W Topeka, *Sylvilagus floridanus,* August 26, 1948 (3 nymphs, reared LJL). NE-

BRASKA. *Webster County:* 3 mi. E Guide Rock, *Heterodon nasicus,* August 5, 1951 (3 nymphs, reared DAC). OKLAHOMA. *Woods County:* 6 mi. S, 2 mi. W Aetna, Kans., *Heterodon platyrhinos,* October 7, 1951 (1 nymph, reared DAC). TEXAS. *Taylor County: Phrynosoma cornutum,* June 10, 1952 (4 nymphs, reared DAC).

Trombicula belkini Gould

(Figs. 23, 79, 229)

Trombicula (Eutrombicula) belkini Gould, 1950, Wasmann Jour. Biol., vol. 8, p. 367 *(larva).*

Description of nymph.—Resembles *T. alfreddugèsi* except as follows:

Body: About 0.7 mm. long, color red. Eyes red, but obscured in mounted materials, detectable by disruption of cuticular striae; about 20 μ in diameter. Setal stem thickened, with many fine branches; tips of posterior setae rounded, slightly expanded, with numerous short branches; posterior setae about 65 μ long. Sternum with about 6 setae. Measurements of tarsus I (means of 6 specimens); TL: 124.5 ± 1.727, TH: 64.7 ± 0.4216, TL/TH: 1.92 ± 0.0308.

Gnathosoma: Cheliceral blade with about 14 teeth. Cheliceral measurements (means of 9 specimens); BL: 114.9 ± 0.8071, BH: 45.1 ± 0.7349, CL: 59.9 ± 0.4233, BL/BH: 2.57 ± 0.0500, BL/CL: 1.92 ± 0.0147. Palpus with dorsal femoral setae profusely branched; tarsala about 9 μ long. Setal counts; femur (7 specimens): 7.21 ± 0.2641, genu (8 specimens): 11.00 ± 0.2631, tibia: range 5-6, tarsus: range 8-10.

Scutum: Sensilla with branches shorter and more numerous; bipectinate on distal portions. Scutal measurements (means of 6 specimens); ASL: 92.8 ± 0.7492, SB: 34.3 ± 0.6062, TS: 33.7 ± 0.9189, SENS: about 100, ASL/SB: 2.73 ± 0.0616.

Remarks.—This species is readily separable from other species of *Trombicula (Eutrombicula)* in the nymphal stage by the form of the posterior body setae. Also, the profuse branching of the setae on the palpal femur is a useable character. The eyes are of interest in *T. belkini;* although they were detected in living material by their color, the actual lens was visible on but one mounted specimen. The striae of the cuticle were disrupted in the area adjacent to the sensillary bases, where the lens should be.

Specimens examined.—Total 9 nymphs, as follows: CALIFORNIA. *Marin County: Sceloporus occidentalis,* June 1, 1952 (9 nymphs, reared DAC).

Trombicula lipovskyana Wolfenbarger

(Figs. 25, 76)

Trombicula (Eutrombicula) lipovskyana Wolfenbarger, 1953, Ann. Ent. Soc. America, vol. 45, pp. 660-666 *(larva, postlarva).*

Description of nymph.—Resembles *T. alfreddugèsi* except as follows:

Body: About 1.0 mm. long, color red. Eyes sometimes obscured, about 20 μ in diameter. Posterior body setae slightly shorter, about 50 μ long. Sternum with about 12 setae. Measurements of tarsus I (means of 8 specimens); TL: 149.0 ± 3.742, TH: 81.3 ± 2.102, TL/TH: 1.85 ± 0.0191.

Gnathosoma: Cheliceral blade with about 22 teeth. Cheliceral measurements (means of 10 specimens); BL: 140.0 ± 2.936, BH: 61.4 ± 0.8326, CL: 84.4 ± 1.0872, BL/BH: 2.32 ± 0.0359, BL/CL: 1.66 ± 0.0276. Palpus large; tarsala about 13 μ long. Setal counts; femur: 6.5 ± 0.2835 (8 specimens), genu: 14.05 ± 0.3877 (10 specimens), tibia: range 4-6, tarsus: range 8-10.

Scutum: Measurements (means of 10 specimens); ASL: 116.9 ± 1.656, SB: 47.9 ± 0.8360, TS: 35.9 ± 2.0911, SENS: about 140, ASL/SB: 2.44 ± 0.0400.

Remarks.—As larva, this species is very close to *T. alfreddugèsi,* but as nymph its affinities appear to be with *T. splendens.* Indeed *T. lipovskyana* may be a subspecies of *T. splendens.* The distribution of *T. lipovskyana* is not well known; apparently it is distributed throughout the southeastern United States (see Loomis, 1956:1280). The habitat of the postlarvae is similar to that of *T. alfreddugèsi,* being grassy soil.

Specimens examined.—Total 24 nymphs, as follows: KANSAS. *Douglas County:* 3 mi. S, 1 mi. E Lawrence, *Sylvilagus floridanus,* July 14, 1949 (11 nymphs, reared LJL); 2 mi. W Lawrence, *Sylvilagus floridanus,* June 19, 1949 (7 nymphs, reared LJL). LOUISIANA. *Jefferson Parish: Anolis carolinensis,* April 28, 1954 (2 nymphs, reared RBL-DAC, idet. by larval skins). *Orleans Parish:* 15 mi. NE New Orleans, *Anolis carolinensis,* April 27, 1954 (4 nymphs, reared RBL, 2 idet. by larval skins).

Trombicula splendens Ewing

(Figs. 13-15, 24, 75, 176, 199, 228)

Trombicula splendens Ewing, 1913, Bull. Amer. Mus. Nat. Hist., vol. 32, pp. 113-114 *(adult).*

Trombicula (Eutrombicula) splendens, Jenkins, 1949, Ann. Ent. Soc. America, vol. 42, p. 304 *(adult);* Wolfenbarger, 1953, Ann. Ent. Soc. America, vol. 45, p. 650 *(adult).*

Trombicula (Trombicula) splendens, Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 334 *(adult).*

Description of nymph.—Resembles *T. alfreddugèsi* except as follows:

Body: About 1.0 mm. long, color red (rarely white). Eyes about 20 μ in diameter. Tips of posterior setae usually with 3 short branches, rarely with 2; posterior setae about 60 μ long. Measurements of tarsus I (means of 9 specimens); TL: 142.8 ± 1.793, TH: 77.1 ± 1.148, TL/TH: 1.83 ± 0.167.

Gnathosoma: Cheliceral blade with about 20 teeth. Cheliceral measurements (means of 10 specimens); BL: 140.8 ± 1.332, BH: 55.9 ± 0.5859, CL: 77.8 ± 0.7859, BL/BH: 2.51 ± 0.0348, BL/CL: 1.81 ± 0.0179. Palpus large, tarsala about 14 μ long. Setal counts; femur (9 specimens): 5.06 ± 0.2324, genu (3 specimens): 12.88 ± 0.5774, tibia: range 5-7, tarsus: range 8-10.

Scutum: Measurements (means of 10 specimens); ASL: 114.6 ± 2.202, SB: 45.3 ± 2.791, TS: 44.6 ± 1.248, SENS: about 140, ASL/SB: 2.53 ± 0.0298.

Remarks.—As in the case of *T. alfreddugèsi,* the foregoing synonomy contains only the more important references to postlarvae of the species. Womersley's description of the sensilla as nude is at variance with my findings.

This species is known from Kansas from adults only. Adults taken on several occasions in decaying logs in Miami County were identified by larvae obtained in culture as *T. splendens.* Most of the nymphs here described are second generation, being reared in such a culture of materials from Titus County, Texas.

Trombicula splendens was originally described from adults. The proper larval form was associated by Jenkins (1949:201).

Specimens examined.—Total 20 nymphs, as follows: LOUISIANA. *St. Charles Parish:* 17 mi. SW New Orleans, *Agkistrodon piscivorous,* May 1, 1954 (1 nymph, reared RBL, idet. by larval skin).

TEXAS. *Titus County:* 3 mi. NW Talco, March 26, 1951 (Adults taken from decaying logs; second generation nymphs obtained; total 19).

Subgenus *Neotrombicula* Hirst

Neotrombicula Hirst, 1925, Nature, vol. 116, p. 609 (type *Acarus autumnalis* Shaw) *(larva).*

Trombicula (Neotrombicula), Brennan and Wharton, 1950, American Midl. Nat., vol. 44, p. 156 *(adult);* Philip and Fuller, 1950, Parasit., vol. 40, pp. 54-55 *(postlarvae);* Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 349 *(adult).*

Diagnosis (nymph).—None.

Remarks.—I find no character or group of characters which permit recognition of this subgenus. Therefore it is left without diagnosis in the nymphal stage, although larvae can be recognized.

Certain features of possible subgeneric importance should be mentioned. The four species studied by me have stout cheliceral bases and wide blades, with rather large teeth. The least extreme is *T. autumnalis,* which has chelicerae more similar to those of *Trombicula (Eutrombicula).* Sensilla tend to be thickened and provided with small branches (except *T. sylvilagi*). In these features the species resemble some members of *Euschöngastia* more closely than they resemble other species of *Trombicula.* It is interesting to note that in both genera the species so modified are fall and winter chiggers. A better source of group characters for these species appears to be the scutum. The species all have similar scuta but I have not been able to find a character which separates them from nymphs of other *Trombicula* species. A very possible character involves the bulla of the sensillary area, which is somewhat enlarged and either lacks a carina or has a short, thick carina almost indistinguishable from the bulla itself. This single feature would not exclude some other species of *Trombicula* from the subgenus *Neatrombicula.*

Nymphs of at least three species of the subgenus *Neotrombicula* have been previously described. *Trombicula pomeranzevi* Schluger has been described by Sasa. André has described the nymph of *T. autumnalis.* Several descriptions are available of postlarvae of *T. japonica* Tanaka but these are inconsistent; the nymph described by Womersley (1952:318, after Tanaka) is certainly not the same as that described by Sasa (1953:423), as noted by Sasa.

Trombicula autumnalis (Shaw)

(Figs. 52, 82, 157, 236)

Acarus autumnalis Shaw, 1790, Naturae vivarii (Nat. Misc.), vol. 2 (no pagination) *(larva).*

Trombicula autumnalis, Kneissl, 1916, Zool. Anz., vol. 46, p. 253 *(nymph);* Hirst, 1915, Jour. Econ. Biol., vol. 10, p. 73 *(nymph);* Philip and Fuller, 1950, Parasit., vol. 40, p. 55 *(nymph);* Richards, 1950, Parasit., vol. 40, pp. 105, 115 *(postlarvae);* Jones, 1951, Parasit., vol. 41, pp. 241-245 *(postlarvae);* Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 364 *(postlarvae).*

Thrombicula autumnalis, André, 1929, Bull. Must. d'Hist. Nat. Paris, 2e Ser., vol. 1, p. 394 *(adult);* André, 1930, Mem. Zool. Soc. France, vol. 29, pp. 39-138 *(postlarvae);* André, 1937, Bull. Mus. d'Hist. Nat. Paris, vol. 9, p. 313 *(adult).*

Description of nymph.—Body: Elongated, about 0.7 mm. long, color not known. Setae normal, with long branches; tips composed of 1 or 2 somewhat long branches; posterior setae about 70 μ long. Sternum roughly pentagonal, closed behind, with about 10 setae. Measurements of tarsus I (means of 9 specimens); TL: 154 ± 5.077, TH: 71.4 ± 1.271, TL/TH: 2.13 ± 0.0441.

Gnathosoma: Chelicera nearly of usual shape, perhaps slightly robust; base punctate; blade with about 15 teeth. Cheliceral measurements (means of 10 specimens); BL: 122.4 ± 2.509, BH: 49.2 ± 0.8138, CL: 70.5 ± 1.014, BL/BH: 2.51 ± 0.0568, BL/CL: 1.73 ± 0.0213. Palpus somewhat stout, very similar to that of *T. lipovskyi;* tarsala about 11 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 10 specimens); femur: 5.17 ± 0.1179, genu: 8.3 ± 0.2135, tibia: range 4-5, tarsus: range 9-10.

Scutum: Tectum broad, with about 12 teeth on margin, very irregular. Sensillary area broadly triangular in shape; basal plate of two widely separated bands; apodeme conspicuous; strong ridges anterior and posterior to sensillary bases; ridges medial to sensillary bases very weak, posterior ridge very weak; bulla triangular, short and broad, punctate; carina not seen; sensillary bases rather small; sensilla somewhat thickened, with short branches on basal thirds and longer ones on distal portions. Scutal measurements (means of 9 specimens); ASL: 97.0 ± 4.384, SB: 44.3 ± 1.476, TS: 34.9 ± 1.493, SENS: about 115, ASL/SB: 2.19 ± 0.0423.

Remarks.—I am indebted to Mr. D. M. Minter for these specimens of *T. autumnalis.*

Trombicula autumnalis is probably the species best known as postlarva, thanks to the careful works of André (particularly the 1930 paper), Richards (1950), and Jones (1951).

Specimens examined.—Total 10 nymphs, as follows: ENGLAND. *Kent:* Chevenins Park, August-September, 1954, "wild rabbits," (10 nymphs, reared by D. M. Minter; associated with larvae of normal type "B" of Richards).

Trombicula lipovskyi Brennan and Wharton

(Figs. 47, 83, 116, 117, 158, 240)

Trombicula (Neotrombicula) lipovskyi Brennan and Wharton, 1950, American Midl. Nat., vol. 44, p. 177 *(larva);* Kardos, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 91-98 *(larva).*

Description of nymph.—Body: Rounded, about 0.6 mm. long, color yellow to orange. Setae with stems slightly thickened, branches fine; tips of posterior setae rounded, with about 3 rather long branches; posterior setae about 45 μ long. Sternum pentagonal, closed behind, with about 6-8 setae. Measurements of tarsus I (means of 10 specimens); TL: 128.9 ± 3.971, TH: 64.6 ± 1.628, TL/TH: 2.00 ± 0.0259.

Gnathosoma: Chelicera with both base and blade robust; base punctate, blade with about 11 teeth of intermediate size. Cheliceral measurements (means of 39 specimens); BL: 117.1 ± 1.135, TH: 48.9 ± 0.4778, CL: 64.3 ± 0.4776, BL/BH: 2.41 ± 0.0275, BL/CL: 1.83 ± 0.0172. Palpus of usual shape; claw slightly elongated; tarsala about 11 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 10 specimens); femur: 4.00 ± 0.4887, genu: 8.2 ± 0.3092, tibia: range 3-5, tarsus: range 8-10.

Scutum: Tectum triangular in shape, margin with about 10 teeth. Sensillary area markedly triangular in shape; apodeme conspicuous; ridges rather strong but usually distorted; bulla triangular, prominent, apparently highly arched; carina not seen; sensillary bases of usual size; sensilla somewhat thickened, flexible, with short branches distributed along entire length, with few longer branches near tips; stems often but not always furcate at tips. Scutal measurements (means of 10 specimens); ASL: 83.8 ± 1.373, SB: 38.1 ± 0.994, TS: 36.5 ± 1.046, SENS: about 110, ASL/SB: 2.21 ± 0.0586.

Remarks.—*Trombicula lipovskyi* was reared to the adult stage. Nymphs ate Collembola eggs.

This species is a common chigger in the eastern part of the Midwest Region. Its closest relative in both larval and nymphal stages appears to be *T. whartoni.*

Specimens examined.—Total 153 nymphs, as follows: KANSAS. *Barber County:* 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus,* April

11, 1949 (12 nymphs, reared LJL). *Douglas County:* Lawrence, *Microtus ochrogaster,* March 5, 1949 (1 nymph, reared LJL), —*Sigmodon hispidus,* October 15, 1948 (1 nymph, reared LJL), and *Neotoma floridana,* March 30, 1949 (4 nymphs, reared LJL); 3 mi. W Lawrence, *Neotoma floridana,* March 5, 1949 (8 nymphs, reared LJL)—*Sylvilagus floridanus,* November 12, 1949 (46 nymphs, reared LJL); 9 mi. W Lawrence, *Sylvilagus floridanus,* January 2, 1949 (6 nymphs, reared LJL); 4 mi. N, 1 mi. E Lawrence, *Neotoma floridana,* November 26, 1948 (9 nymphs, reared LJL); 2 mi. S, 2 mi. W Pleasant Grove, *Sylvilagus floridanus,* March 3, 1949 (1 nymph, reared LJL), December 4, 1948 (1 nymph, reared LJL), and December 29, 1948 (1 nymph, reared LJL); 3 mi. S Eudora, *Sylvilagus floridanus,* February 17, 1949 (1 nymph, reared LJL); 3 mi. W, 2 mi. S Clinton, *Sylvilagus floridanus,* March 10, 1949 (1 nymph, reared LJL). *Jefferson County:* 6 mi. E Perry, *Neotoma floridana,* December 28, 1948 (3 nymphs, reared LJL); 5½ mi. N, ½ mi. E Lawrence, *Sylvilagus floridanus,* November 21, 1951 (17 nymphs, reared DAC), and November 24, 1951 (4 nymphs, reared DAC). *Johnson County:* 2 mi. N, 1 mi. W Lenexa, *Sylvilagus floridanus,* November 18, 1953 (13 nymphs, reared RBL). *Wyandotte County:* Kansas City, *Sylvilagus floridanus,* October 30, 1953 (1 nymph, reared RBL), and December 21, 1953 (3 nymphs, reared RBL). OKLAHOMA. *Woods County:* 6 mi. S, 2 mi. W Aetna, Kans., *Heterodon platyrhinos,* October 7, 1951 (1 nymph, reared DAC).

Trombicula sylvilagi Brennan and Wharton

(Figs. 53, 160, 237)

Trombicula (*Neotrombicula*) *sylvilagi* Brennan and Wharton, 1950, Amer. Midl. Nat., vol. 44, pp. 186-187 (*larva*); Kardos, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 103-111 (*larva*).

Description of nymph—Resembles *T. lipovskyi* except as follows:

Body: Elongated, small (0.5 mm. long), color orange. Setae short, stems thick; tips rounded, with 2-3 short branches; posterior setae about 25 μ long. Measurements of tarsus I (means of 5 specimens); TL: 101.4 ± 0.600, TH: 55.0 ± 0.632, TL/TH: 1.84 ± 0.0283.

Gnathosoma: Cheliceral base with conspicuously large puncta; blade with about 10 particularly large teeth. Cheliceral measurements (means of 4 specimens); BL: 85.3 ± 1.315, BH: 37.5 ± 0.866, CL: 52.5 ± 1.255, BL/BH: 2.25 ± 0.0646, BL/CL: 1.63 ± 0.0629. Palpus with tarsala about 9 μ long. Setal counts; femur (1 specimen): 3.5, genu (3 specimens): 6.50 ± 0.2887, tibia: range 4-5, tarsus: 9.

Scutum: Sensilla with short branches on basal thirds, longer ones on distal portions (resembling *T. autumnalis*), stems slightly expanded distally. Scutal measurements (means of 5 specimens); ASL: 65.4 ± 1.0296, SB: 34.2 ± 0.800, TS: 14.3 ± 0.4787, SENS: about 75, ASL/SB: 1.92 ± 0.0490.

Remarks.—As a larva, this species was listed by Brennan and Wharton as "ungrouped," since it did not appear closely related to other species in *Neotrombicula.* As a nymph, *T. sylvilagi* is not markedly different from *T. lipovskyi,* except in being smaller. Until more postlarvae of *Neotrombicula* are known, it is not possible to evaluate "groups" of species in *Neotrombicula* except on larval characters.

The specimens studied were reared by Ervin H. Kardos in an unusual manner. Unengorged larvae were obtained with chigger samplers and were then allowed to attach to a laboratory mammal (*Mus*). Nymphs were then obtained from these larvae.

Specimens examined.—Total 5 nymphs, as follows: KANSAS. *Douglas County:* Univ. Kansas Natural History Reservation, *chigger sampler,* October 8, 1952 (5 nymphs, reared EHK).

Trombicula whartoni Ewing

(Figs. 51, 80, 159)

Trombicula whartoni Ewing, 1929, Ent. News, vol. 40, p. 296 (*larva*).
Trombicula (*Neotrombicula*) *whartoni,* Brennan and Wharton, 1950, Amer. Midl. Nat., vol. 44, pp. 175-176 *(larva);* Kardos, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 98-102 (*larva*).

Description of nymph.—Resembles *T. lipovskyi* except as follows:

Body: About 0.7 mm. long. Measurements of tarsus I (means of 9 specimens); TL: 148.2 ± 2.101, TH: 77.9 ± 1.012, TL/TH: 1.91 ± 0.0247.

Gnathosoma: Chelicerae nearly normal in shape, perhaps slightly robust; base with conspicuous puncta; blade with about 15 teeth of intermediate size. Cheliceral measurements (means of 9 specimens); BL: 120.6 ± 1.925, BH: 47.1 ± 1.181, CL: 65.9 ± 0.8233, BL/BH: 2.58 ± 0.0843, BL/CL: 1.83 ± 0.0211. Palpus with tarsala about 11 μ long; tarsus with 3 inner, 2-3 outer apical nude setae. Setal counts; femur (6 specimens); 6.00 ± 0.3874, genu (9 specimens): 10.17 ± 0.4714, tibia: range 4-6, tarsus: range 10-15.

Scutum: Sensillary area with bulla with conspicuous puncta; sensilla nude except for small basal branches, rarely furcate at tips. Scutal measurements (means of 9 specimens); ASL: 101.9 ± 1.775, SB: 42.8 ± 1.038, TS: 40.3 ± 1.291, SENS: about 145, ASL/SB: 2.41 ± 0.0484.

Remarks.—The nymph is similar to that of *T. lipovskyi* but is easily differentiated by its nude sensilla. Loomis (1956:1295) suggests that *T. whartoni* seems restricted to deciduous woods and the woodland edge, while *T. lipovskyi* occurs in the drier open grasslands but also in the woodland edge.

Trombicula whartoni was less frequently collected than *T. lipovskyi*, but the difference is not so great as to explain why no *T. whartoni* nymphs appeared in the mixed cultures maintained by L. J. Lipovsky. On the two occasions when the species was successfully cultured, the cultures were pure.

Specimens examined.—Total 9 nymphs, as follows: KANSAS. *Douglas County:* 2 mi. S Warden, *Sciurus niger*, November 28, 1949 (2 nymphs, reared LJL). *Johnson County:* Roeland Park, *Sylvilagus floridanus*, November 4, 1953 (7 nymphs, 1 idet. by larval skin, reared RBL-DAC).

Subgenus *Leptotrombidium* Nagayo, Miyagawa, Mitamura and Imamura

Leptotrombidium Nagayo *et al.*, 1916, Dobutsugaku Zasshi, vol. 28, p. 392 (type *Trombidium akamushi* Brumpt) *(larva).*

Trombicula (Leptotrombidium), Ewing, 1949, J. Washington Acad. Sci., vol. 39, p. 236 *(adult);* Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 326 *(adult);* Sasa, 1953, Japanese Jour. Exp. Med., vol. 23, p. 411 *(postlarvae);* Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 140 *(postlarvae).*

Diagnosis (nymph).—(2) Precoxal plates of coxae I present but fused in midline to form longitudinally divided sternum.

Remarks.—This diagnostic feature for *Leptotrombidium* was first used by Womersley; Sasa and Audy have followed his diagnosis and the nymphs described by Sasa agree with it. The nymph of *T. myotis*, described in the present paper, is the seventeenth species of *T. (Leptotrombidium)* to be known in the postlarva stage.

Prior to Womersley's (1952:326) discovery of the divided sternum as a subgeneric feature, the subgenus *Leptotrombidium* was diagnosed on combinations of larval characters. It seems likely that in the future, workers will place more emphasis on the nymphal stage for recognition of this subgenus. *Leptotrombidium* was expanded by Womersley (1952:326) and further expansion was suggested by Audy (1954:140). The limits of the subgenus are certainly vague at present; it seems doubtful that the single diagnostic feature used for the postlarval stages will stand the test of time.

Trombicula myotis Ewing

(Figs. 55, 81, 106, 107, 166, 231)

Trombicula myotis Ewing, 1929, Ent. News, vol. 40, pp. 294-295 *(larva).*
Trombicula (Leptotrombidium) myotis, Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 54 *(larva);* Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1287-1288 *(larva).*

Description of nymph.—Body: Rounded posteriorly, about 0.6 mm. long, color not known. Setae long, branches fine; tips of posterior setae spatulate, with several short branches; posterior setae about 60 μ long. Sternal division rarely incomplete; each side with about 4 setae. Measurements of tarsus I (means of 4 specimens); TL: 101.3 ± 0.4787, TH: 59.8 ± 0.2500, TL/TH: 1.7 ± 0.000.

Gnathosoma: Cheliceral base somewhat robust, punctate, area of articulation large; blade shearlike, apodeme of blade not constricted, with about 19 small teeth. Cheliceral measurements (means of 4 specimens); BL: 93.0 ± 1.528, BH: 37.8 ± 2.462, CL: 49.8 ± 1.250, BL/BH: 2.63 ± 0.0885, BL/CL: 1.83 ± 0.0408. Palpus of usual shape; tarsala about 11 μ long, claw rather short; tarsus with 3 inner, 1 outer apical nude setae. Setal counts (means of 4 specimens); femur: 4.88 ± 0.0126, genu: 7.00 ± 0.4787, tibia: 5, tarsus: 9.

Scutum: Tectum large, square, with about 10 teeth. Crista narrow. Sensillary area broad, oval; basal plate of two rather large halves; apodeme short; strong ridges anterior and posterior to sensillary bases, others very weak; bulla much reduced, triangular; carina broad but short; sensillary bases prominent; sensilla somewhat thickened but flexible, with short branches on basal half, longer ones on distal half, longer branches fine. Scutal measurements (means of 3 specimens); ASL: 80.3 ± 2.028, SB: 31.3 ± 0.8539, TS: 29.3 ± 0.3334, SENS: about 80, ASL/SB: 2.50 ± 0.0577.

Remarks.—Loomis (1956:1289) suggests that postlarvae of this species are probably inhabitants of decaying wood, and possibly nests of mammals nesting in such places.

The nymph of *T. myotis* cannot be keyed down to species of *T.* (*Leptotrombidium*) in the key given by Womersley (1952:342). Sasa (1953:411) experienced difficulty in separating his nymphs of Japanese species. I am unable to separate *T. myotis* from the nymphs described by Sasa. It appears that the subgenus *Lep-*

totrombidium is a group of species far more readily separable in the larval stage than in postlarval stages.

Specimens examined.—Total 4 nymphs, as follows: IOWA. *Fremont County:* Waubonsie State Park, 5 mi. S, 2 mi. W. Sidney, *Peromyscus leucopus,* October 10, 1953 (4 nymphs, reared RBL).

Subgenus *Trombicula* Berlese

Trombicula Berlese, 1905, Redia, vol. 2, p. 155 (type *Trombicula minor* Berlese) (*adult*).

Diagnosis (*nymph*).—(1) Eyes absent. (2) Precoxal plates absent. (10) Tectum square to triangular, with few to many teeth on margin. (22) Sensillary area with posterior scutal ridge without elevations or with only weak elevations. (23) About eight to twelve parascutal setae.

Remarks.—More realistically, this subgenus contains those species which do not fall into the other subgenera. The impossibility of recognizing *T. minor* has been previously discussed; without a usable type species the subgenus can only serve as a catch-all.

About twenty postlarvae which would apparently fall into this subgenus have been described; about ten of these are known as adults only. Inclusion of these forms in the key to species was not feasible.

Trombicula crossleyi Loomis

(Figs. 132, 133, 163)

Trombicula crossleyi Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 920-922 (*larva*).

Description of nymph.—Body: Small (about 0.5 mm. long), elongated, color orange to red. Setae somewhat short, stem rather thickened, branches fine and numerous; tips of posterior setae with about 3-5 short branches; posterior setae about 20 μ long. Sternal area elongated posteriorly, rectangular in shape, usually open behind, with about 4 setae. Measurements of tarsus I (means of 10 specimens); TL: 77.0 ± 0.7889, TH: 36.8 ± 0.3267, TL/TH: 2.10 ± 0.0298.

Gnathosoma: Cheliceral base of usual shape, puncta almost absent; blade shearlike, with about 14 rather small teeth. Cheliceral measurements (means of 6 specimens); BL: 81.6 ± 1.70, BH: 28.4 ± 0.68, CL: 36.8 ± 0.76, BL/BH: 2.94 ± 0.093, BL/CL: 2.26 ± 0.034. Palpus slightly elongated; dorsal genual setae often nude, claw and accessory claws rather small, tarsala about 6 μ long; tarsus with 2 inner, 1 outer apical nude setae. Setal counts (means of 6 specimens); femur: 3.00 (no variation), genu: 2.83 ± 0.1258; tibia: range 4-5, tarsus: range 7-9.

Scutum: Tectal margin with about 10 conspicuous teeth. Sensillary area nearly transverse-oval in appearance; apodeme reduced; ridges weak, usually distorted; bulla triangular; carina small and thin; sensillary bases prominent; a pair of noticeably elongated parascutal setae directly in front of sensillary area; sensilla straight, slightly expanded distally, branches short on basal half, longer on distal half. Scutal measurements (means of 10 specimens); ASL: 59.2 ± 1.083, SB: 27.3 ± 1.041, TS: 20.8 ± 0.249, SENS; about 65, ASL/SB: 2.18 ± 0.1065.

Remarks.—This species is one of a group which, as nymphs, possesses several key characters apparently associated with somewhat smaller size than most species of *Trombicula.* This group of species contains *T. crossleyi, T. trisetica, T. merrihewi,* and *T. ornata;* some features distinguishing this group are the presence of but three apical nude setae on the palpal tarsus, usually but three setae on the palpal femur, prominent sensillary bases on the scutum (seemingly a reduction of scutal size rather than enlargement of the sensillary bases), and a tendency towards elongation of one pair of parascutal setae. The larvae of these four species are more diverse; larvae of *T. crossleyi* and *T. trisetica* are similar and are undistinguished *Trombicula* species but larvae of *T. merrihewi* and *T. ornata,* while resembling each other, have distinctive scuta and chelicerae.

It is interesting to note that these four species, although similar in morphology in postlarval stages, seemingly exist in different habitats. Loomis (1956:1322), on the basis of larval host preferences, suggests the habitat of postlarvae of *T. crossleyi* and *T. trisetica* to be standing dead trees, and that of *T. ornata* to be crevices of rock outcroppings and possibly nests of mammals, while *T. merrihewi* is known only from bats and postlarvae are assumed to be cave dwellers. Thus it seems likely that the features common to these species are associated with small size rather than being direct adaptations to specific habitats.

Of the species placed in the subgenus *Trombicula,* these four appear to be the most likely relatives of *Trombicula minor.* This relationship is suggested not only by their small size but by comparison of their scuta with the illustration of that of *T. minor,* as given by Willmann (1940:133). As previously noted, Willmann's drawing is diagrammatic and may not be adequate for such comparison.

Trombicula crossleyi is very similar to *T. trisetica* in both larval and postlarval stages, and eventually the two may prove to be

conspecific. Nymphs are difficult to separate; the only differences found involve measurements.

Specimens examined.—Total 12 nymphs, as follows: KANSAS. *Barber County:* 10½ mi. W Hardtner, *Melanerpes erythrocephalus*, July 26, 1952 (5 nymphs, reared DAC); 4 mi. S Aetna, *Peromyscus leucopus*, October 7, 1951 (6 nymphs, reared LJL), July 25, 1952 (1 nymph, reared DAC).

Trombicula fitchi Loomis

(Fig. 230)

Trombicula fitchi Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 926-928 *(larva).*
Trombicula (Neotrombicula) fitchi, Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1297-1298 *(larva).*

Description of nymph.—Body: Rounded, about 0.5 mm. long, color not known. Setae with stems normal, branching distinctive; posterior setae with long fine branches on basal halves but short thick-based branches on distal halves; tips with 2 or 3 short branches; posterior setae about 60 μ long. Sternal area roughly pentagonal in shape, closed behind, with about 8 setae. Measurements of tarsus I (means of 10 specimens); TL: 109 ± 3.157, TH: 53.5 ± 1.046, TL/TH: 2.03 ± 0.0423.

Gnathosoma: Chelicerae of usual shape, base punctate; blade with about 20 rather small teeth. Cheliceral measurements (means of 113 specimens); BL: 111.6 ± 1.819, BH: 38.4 ± 1.071, CL: 55.5 ± 1.096, BL/BH: 2.92 ± 0.0715, BL/CL: 2.01 ± 0.0265. Palpi of usual shape, dorsal genual setae occasionally nude; tarsus with tarsala about 8 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 8 specimens); femur: 3:94 ± 0.2904, genu: 8.13 ± 0.3239, tibia: range 2-5, tarsus: range 8-9.

Scutum: Tectum with about 8 teeth on margin. Sensillary area triangular; basal plate of two bands; apodeme well developed; ridges usually distorted but rather strong; bulla triangular, well developed; carina thick, hard to see; sensilla rather thick but flexible, with short branches basally but somewhat larger branches distally; branches generally few, none large. Scutal measurements (means of 10 specimens); ASL: 92.9 ± 1.853, SB: 35.3 ± 1.033, TS: 33.7 ± 0.5588, SENS: about 125, ASL/SB: 2.63 ± 0.0472.

Remarks.—As nymph, *Trombicula fitchi* is easily recognized by the form of the posterior body setae. Nymphs of *T. kardosi* have similar posterior setae but the two are still sufficiently different to permit easy separation.

Loomis (1956:1290) placed these two species in the subgenus *Neotrombicula* on the basis of larval characteristics. To do so required a broadening of the concept of the subgenus which eliminated the principal key character for the subgenus (the presence of long nude whiplike setae on leg III). In the nymphal as well as in the larval stage, *T. fitchi* and *T. kardosi* appear to me to be related to species of *T.* (*Neotrombicula*), as Loomis suggests. However, it is difficult to determine how close this relationship may be. Until more nymphs of species of *T.* (*Neotrombicula*) are known, I prefer to retain *T. fitchi* and *T. kardosi* in the subgenus *Trombicula.*

Specimens examined.—Total 17 nymphs, as follows: KANSAS. *Barber County:* 3½ mi. S Aetna, *Myotis velifer,* April 10, 1949 (5 nymphs, reared LJL). *Douglas County: Sciurus niger,* January 19, 1950 (2 nymphs, reared LJL); 2 mi. S Warden, *Sciurus niger,* November 26-28, 1949 (10 nymphs, reared LJL).

Trombicula gurneyi Ewing

(Figs. 57, 69, 112, 113, 164, 238)

Trombicula gurneyi Ewing, 1937, Proc. Biol. Soc. Washington, vol. 50, p. 169 *(larva);* Loomis, 1955, Univ. Kansas Sci. Bull., vol. 37, pp. 252-257 *(larva).*

Description of nymph.—Body: Rounded, about 0.6 mm. long, color red to orange. Setae somewhat short, stems rather thickened, branches fine and numerous; tips of posterior setae with about 3 short branches; posterior setae about 30 μ long. Sternum closed behind, roughly pentagonal, with about 6 setae. Measurements of tarsus I (means of 11 specimens); TL: 103.0 ± 3.555, TH: 53.4 ± 1.330, TL/TH: 1.93 ± 0.0557.

Gnathosoma: Cheliceral base of usual shape, puncta few; blade shearlike, with about 16 teeth. Cheliceral measurements (means of 8 specimens); BL: 94.1 ± 1.865, BH: 36.0 ± 1.210, CL: 49.8 ± 1.146, BL/BH: 2.63 ± 0.0525, BL/CL: 1.88 ± 0.0249. Palpus of usual shape; tarsala about 11 μ long; tarsus with 3 inner, 2 outer apical nude setae. Setal counts (means of 9 specimens); femur: 4.94 ± 0.2693, genu: 8.50 ± 0.2635, tibia: range 4-5, tarsus: range 8-10.

Scutum: Tectum with about 8 rather small teeth. Sensillary area triangular; basal plate of two widely separated bands; apodeme prominent; bulla triangular; carina thin, long; ridges rather strong, ridges medial to sensillary bases fused with posterior ridge and somewhat prominent at this point (resembling members of the sub-

genus *Eutrombicula*); sensilla flagelliform, flexible, stems thin and finely tapered, with basal branches short and distal branches few, fine, and long. Scutal measurements (means of 11 specimens); ASL: 80.1 ± 2.605, SB: 37.4 ± 1.171, TS: 30.4 ± 1.974, SENS: about 100, ASL/SB: 2.11 ± 0.0489.

Remarks.—Trombicula gurneyi is closely related to *T. kansasensis*, as seen in both larval and nymphal stages. The species may be separated by the larger size and elongated cheliceral base of *T. kansasensis*.

These two species show puzzling similarities to members of the subgenus *Eutrombicula* in the nymphal stage. Both species have the fine flagelliform sensilla with fine branches and the "bilobed" appearance of the posterior scutal ridge, although this latter feature is not so pronounced as in true *Eutrombicula*.

Trombicula gurneyi is rather easily cultured and has been reared through a complete generation in the laboratory. Food of the postlarval stages was collembolan eggs.

Specimens examined.—Total 16 nymphs, as follows: ARKANSAS. *Little River County:* 5 mi. S Ashdown, *Eumeces laticeps*, May 3, 1954 (4 nymphs, reared RBL-DAC). KANSAS. *Barber County:* Aetna, *Dipodomys ordii*, July 11, 1955 (2 nymphs, reared DAC); 2 mi. S Aetna, *Dipodomys ordii*, September 14, 1953 (1 nymph, reared DAC, idet. by larval skin): 4 mi. S Aetna, *Peromyscus maniculatus*, October 7, 1951 (1 nymph, reared LJL). *Douglas County:* Univ. Kansas Natural History Reservation, *Eumeces fasciatus*, June 27, 1952 (2 nymphs, reared DAC), and *Peromyscus maniculatus*, October 20, 1951 (3 nymphs, reared DAC). *Rawlins County: Citellus tridecemlineatus*, July 28, 1948 (2 nymphs, reared LJL). NEBRASKA. *Webster County:* 3 mi. E Guide Rock, *Heterodon nasicus*, August 5, 1951 (1 nymph, reared LJL).

Trombicula kansasensis Loomis

(Figs. 56, 77, 114, 115)

Trombicula kansasensis Loomis, 1955, Univ. Kansas Sci. Bull., vol. 37, pp. 260-262 (*larva*).

Description of nymph.—Resembles *T. gurneyi* except as follows:

Body: About 0.8 mm. long, color orange. Setae similar to those of *T. gurneyi* but longer; posterior setae about 65 μ long. Sternum with 4 setae (1 specimen). Measurements of tarsus I (1 specimen); TL: 128, TH: 58, TL/TH: 2.2.

Gnathosoma: Cheliceral base elongated, punctate, area of articulation elongated; apodeme of blade strongly constricted; blade with about 18 teeth. Cheliceral measurements (1 specimen); BL: 120, BH: 40, CL: 62, BL/BH: 3.0, BL/CL: 1.9. Palpus large, rather elongated, tarsala about 12 μ long. Setal counts (1 specimen); femur: 6, genu: 10, tibia: 5, tarsus: 9.

Scutum: Measurements (1 specimen); ASL: 104, SB: 40, TS: 46, ASL/SB: 2.6.

Remarks.—The key couplet separating *T. kansasensis* from *T. gurneyi* uses the longer cheliceral base of *kansasensis.* A second character is the length of the posterior body setae; those of *kansasensis* are twice as long as those of *gurneyi.*

Specimens examined.—Total 1 nymph, as follows: KANSAS. *Barber County:* 4 mi. S Aetna, *Neotoma micropus,* July 11, 1955 (1 nymph, reared DAC, idet. by larval skin).

Trombicula kardosi Loomis

(Figs. 59, 78, 161, 174, 175)

Trombicula kardosi Loomis, 1954, Univ. Kansas Sci. Bull., vol. 36, pp. 929-930 (*larva*).

Trombicula (*Neotrombicula*) *kardosi,* Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1299 (*larva*).

Description of nymph.—Resembles *T. fitchi* except as follows:

Body: About 0.6 mm. long, color orange. Setae similar to those of *T. fitchi,* but posterior setae with occasional long branches among shorter branches of distal halves; posterior setae about 65 μ long. Measurements of tarsus I (means of 7 specimens); TL: 108 ± 1.091, TH: 56.1 ± 1.534, TL/TH: 1.93 ± 0.0565.

Gnathosoma: Cheliceral blade with about 17 small teeth. Cheliceral measurements (means of 7 specimens); BL: 111.0 ± 0.7228, BH: 38.6 ± 1.042, CL: 54.4 ± 0.8401, BL/BH: 2.89 ± 0.0799, BL/CL: 2.04 ± 0.0368. Palpus with tarsala about 11 μ long. Setal counts; femur (5 specimens): 3.3 ± 0.1225; genu (6 specimens): 7.83 ± 0.1923, tibia: range 3-5, tarsus: range 8-9.

Scutum. Generally resembles that of *T. fitchi;* sensilla usually with more numerous branches, resembling those of *T. lipovskyi.* Scutal measurements (means of 6 specimens); ASL: 94.2 ± 2.057, SB: 36.8 ± 0.4474, TS: 27.6 ± 0.2974, SENS: about 125, ASL/SB: 2.57 ± 0.0761.

Specimens examined.—Total 7 nymphs, as follows: KANSAS. *Douglas County:* 4½ mi. W, 3 mi. S Baldwin, *Sciurus niger,* November 28, 1951 (7 nymphs, reared DAC).

Trombicula merrihewi Loomis and Lipovsky
(Figs. 38, 89, 136, 137, 165, 181, 232)

Trombicula merrihewi Loomis and Lipovsky, 1954, Jour. Kansas Ent. Soc., vol. 27, p. 51 *(larva).*

Description of nymph.—Resembles *T. crossleyi* except as follows:

Body: About 0.6 mm. long, color not known. Body setae short; branches fine, long, rather sparse; tips of posterior setae of 2 or 3 branches; posterior setae about 14 μ long. Measurements of tarsus I (means of 10 specimens); TL: 69.0 ± 0.6146, TH: 36.5 ± 0.4281, TL/TH: 1.89 ± 0.0278.

Gnathosoma: Cheliceral base punctate; blade with about 14 small teeth. Cheliceral measurements (means of 10 specimens); BL: 76.8 ± 0.827, BH: 28.2 ± 0.512, CL: 33.0 ± 0.516, BL/BH: 2.75 ± 0.0401, BL/CL: 2.32 ± 0.0359. Palpus with claw more normal in shape; tibial setae nude or nearly so; tarsus with setae with reduced branching, tarsala about 7 μ long. Setal counts (means of 10 specimens); femur: 3.0 (no variation); genu: 4.75 ± 0.1539, tibia: range 4-5, tarsus: range 8-9.

Scutum: Tectum with about 8 prominent teeth on margin. Sensillary area triangular in appearance; strong ridges posterior to sensillary bases, others weak; bulla apparently unusually elevated; carina thick; without unsually elongated parascutal setae; sensilla subclavate. Scutal measurements (means of 10 specimens); ASL: 59.1 ± 1.120, SB: 25.1 ± 0.888, TS: 19.4 ± 0.612, SENS: about 60, ASL/SB: 2.38 ± 0.0789.

Remarks.—This species is readily recognized by the unusually short (14 μ) posterior body setae.

The occurrence of larvae on bats strongly suggests that the nymphs inhabit caves. Of the characters given above, the reduced branching of the palpal setae seems most likely to be a modification for this habitat. Of the species probably dwelling in caves as postlarvae, *Speleocola tadaridae* also has reduced branching of palpal setae, but *Whartonia sensae* and *Euschöngastia pipistrelli* do not. Also, *Trombicula ornata,* a species related to *T. merrihewi,* but not taken from bats, shows a similar reduction in branching.

Specimens examined.—Total 19 nymphs, as follows: OKLAHOMA. *Woods County:* 6 mi. S, 2 mi. W Aetna, Kans., *Tadarida mexicana,* August 24, 1949 (19 nymphs, reared LJL).

Trombicula montanensis Brennan

(Figs. 9, 12, 54, 73, 122, 123, 167, 239)

Trombicula montanensis Brennan, 1946, Jour. Parasit., vol. 32, pp. 441-442 *(larva);* Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1306-1310 *(larva).*

Description of nymph.—Body: About 0.6 mm. long, rounded, color yellow to orange. Setae with thick stems, rather short; branches fine, numerous; posterior setae with tips somewhat rounded, with several tiny branches; posterior setae about 30 μ long. Sternal area variable; usually closed behind but rarely open; usually about pentagonal in shape but rarely elongated-rectangular; with about 8 setae. Measurements of tarsus I (means of 17 specimens); TL: 89.9 ± 1.6997, TH: 45.1 ± 0.8613, TL/TH: 1.99 ± 0.0251.

Gnathosoma: Cheliceral base of usual shape, punctate; blade normal, with about 13 teeth of intermediate size. Cheliceral measurements (means of 9 specimens); BL: 90.8 ± 1.9985, BH: 33.6 ± 0.7094, CL: 46.2 ± 0.8127, BL/BH: 2.71 ± 0.0611, BL/CL: 1.96 ± 0.0176. Palpus of usual shape; dorsal genual setae often nude; claw and accessory claws rather small; dorsal tibial setae occasionally nude; tarsus with tarsala about 9 μ long; tarsus with 3 inner, 1 outer apical nude setae. Setal counts (means of 9 specimens); femur: 4.00 ± 0.2079, genu: 8.28 ± 0.1900, tibia: range 4-5, tarsus: 9.

Scutum: Tectal margin with about 10 teeth. Sensillary area triangular in appearance; basal plate rather simple, of two halves; apodeme well developed; bulla triangular, prominent, conspicuously domelike; carina thick, only slightly elevated, often difficult to distinguish from bulla; posterior ridge weak, ridges medial to sensillary bases weak, others strong; sensilla with short branches basally but longer ones distributed over rest of stems, stems flexible, flagelliform or slightly thickened. Scutal measurements (means of 16 specimens); ASL: 71.8 ± 0.9593, SB: 32.4 ± 0.7161, TS: 22.7 ± 0.506, SENS: about 80, ASL/SB: 2.26 ± 0.0418.

Remarks.—*Trombicula montanensis* is a common chigger of the central states region. The best recognition character for nymphs seems to be the four apical nude setae of the palpal tarsus; other species of *Trombicula (Trombicula)* have either three, five, or six such setae.

Nymphs of *T. montanensis* show considerable variation in morphology. The shape of the sternal area, which is relatively constant for other species, is dimorphic in *montanensis;* occasional specimens from Barber County, Kansas, possess an elongated-rectangular sternum which is open behind, instead of the usual closed pentagonal sternum. Other variation is noticeable in the scutal area. A carina is plainly visible on some specimens but is not visible on other equally well-mounted specimens. A dimorphic condition of the sensilla occurs also; the two distinct forms are a flagelliform stem resembling that of *T. gurneyi* and a slightly thickened stem resembling that of *T. lipovskyi.* The more common type is the latter one, but occasional specimens from Barber County, Kansas, and Webster County, Nebraska, have flagelliform sensilla. The flagelliform type is more prevalent in a series of 68 nymphs from Barber County collected in August of 1948, but is uncommon on specimens taken in 1949, 1952, and 1953 in Barber County. Associated larvae show no unusual variation.

The reasons behind these unusual variations are not known. The specimens at hand are not sufficient to indicate whether genetic or environmental forces produce these effects.

Nymphs and adults of *T. montanensis* feed readily upon collembolan eggs. This species has been reared through a complete generation.

Specimens examined.—Total 108 nymphs, as follows: KANSAS. *Barber County:* 5 mi. E Aetna, *Perognathus hispidus,* July 26, 1952 (4 nymphs, reared DAC, 1 idet. by larval skin); 4½ mi. S, 1 mi. W Aetna, *Citellus tridecemlineatus,* September 16, 1953 (2 nymphs, reared DAC) and *Cynomys ludovicianus,* September 16, 1953 (1 nymph, reared DAC); 4 mi. S Aetna, *Neotoma micropus,* August 22, 1948 (68 nymphs, reared LJL); 10½ mi. W Hardtner, *Cynomys ludovicianus,* August 21, 1949 (5 nymphs, reared LJL), and July 26, 1952 (7 nymphs, reared DAC); 3½ mi. W Hardtner, *Cynomys ludovicianus,* August 23, 1949 (1 nymph, reared LJL). *Rawlins County:* 11 mi. S McDonald, *Cynomys ludovicianus,* July 27, 1948 (1 nymph, reared LJL). *Seward County:* 4 mi. NE Liberal, *Masticophis flagellum,* September 12, 1948 (1 nymph, reared LJL). NEBRASKA. *Hitchcock County:* 4 mi. E Stratton, *Cynomys ludovicianus,* August 8, 1949 (1 nymph, reared LJL); 13 mi. S Trenton, *Citellus tridecemlineatus,* August 8, 1949 (9 nymphs, reared LJL).

Webster County: 3 mi. E Guide Rock, *Heterodon nasicus,* August 5, 1951 (7 nymphs, reared DAC). OKLAHOMA. *Woods County:* 6 mi. S, 2 mi. W Aetna, Kans., *Heterodon platyrhinos,* October 7, 1951 (1 nymph, reared DAC).

Trombicula ornata Loomis and Lipovsky

(Figs. 58, 162, 202)

Trombicula ornata Loomis and Lipovsky, 1954, Jour. Kansas Ent. Soc., vol. 27, p. 47 (*larva*).

Description of nymph.—Resembles *T. crossleyi* except as follows:

Body: About 0.7 mm. long, rather rounded, color not known. Posterior setae about 25 μ long. Sternal area larger than that of *T. crossleyi,* with about 4 to 6 setae. Measurements of tarsus I (means of 7 specimens); TL: 90.1 ± 2.176, TH: 38.7 ± 0.6801, TL/TH: 2.34 ± 0.0812.

Gnathosoma: Cheliceral base unusually elongated, area of articulation elongated; blade rather stout but shearlike, with about 17 small teeth. Cheliceral measurements (means of 7 specimens); BL:111.3 ± 1.229, BH: 30.7 ± 0.5217, CL: 39.4 ± 0.7189, BL/BH: 3.63 ± 0.1286, BL/CL: 2.83 ± 0.0474. Palpus with claw more normal in size; accessory claw thin; tibial setae nude or nearly so; tarsala about 9 μ long. Setal counts (6 specimens); femur: 3.00 (no variation); genu: 4.79 ± 0.4062, tibia: range 4-5, tarsus: 9.

Scutum: Sensillary area markedly triangular in shape; strong ridges anterior to and posterior to sensillary bases, others weak; sensillary bases not unusually prominent. Scutal measurements (means of 6 specimens); ASL: 72.2 ± 0.9700, SB: 28.9 ± 0.5084, TS: 24.7 ± 0.7603, SENS: about 75, ASL/SB: 2.48 ± 0.0538.

Remarks.—This species appears most similar to *Trombicula merrihewi,* although similarities are more obvious in the larval stage than in the nymphal stage. *Trombicula ornata* resembles the larger *Trombicula* species almost as much as it resembles *T. crossleyi* and relatives, but the affinities of *ornata,* through *merrihewi,* would seem to be with *crossleyi* and *trisetica.*

Trombicula ornata is easily separated from these species by the elongated cheliceral base which it possesses.

Specimens examined.—Total 18 nymphs, as follows: KANSAS. *Barber County:* 3½ mi. S, 1 mi. W Aetna, *Neotoma micropus,* April 11, 1949 (16 nymphs, reared LJL); 4 mi. S Aetna, *Neotoma micropus,* August 22, 1949 (2 nymphs, reared LJL).

Trombicula trisetica Loomis and Crossley

(Figs. 1-7, 198)

Trombicula trisetica Loomis and Crossley, 1953, Jour. Kansas Ent. Soc., vol. 26, p. 32 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1321-1323 (*larva*).

Description of nymph.—Resembles *T. crossleyi* except as follows:

Body: About 0.6 mm. long. Posterior setae about 25 μ long. Measurements of tarsus I (means of 10 specimens); TL: 82.8 ± 1.397, TH: 40.1 ± 0.647, TL/TH: 2.09 ± 0.0277.

Gnathosoma: Cheliceral base punctate; blade with about 17 small teeth. Cheliceral measurements (means of 10 specimens); BL: 90.5 ± 1.046, BH: 30.4 ± 0.3711, CL: 40.5 ± 0.2687, BL/BH; 2.91 ± 0.0407, BL/CL: 2.19 ± 0.0278. Palpus with tarsala about 9 μ long. Setal counts (means of 10 specimens); femur: 2.95 ± 0.0049, genu: 3.00 (no variation); tibia: range 5-6, tarsus: 9.

Scutum: Sensilla less expanded than those of *T. crossleyi*, distal branches somewhat longer. Scutal measurements (means of 10 specimens); ASL: 66.1 ± 1.059, SB: 30.3 ± 0.7753, TS: 22.8 ± 0.4163, SENS: about 85, ASL/SB: 2.21 ± 0.0722.

Specimens examined.—Total 18 nymphs, as follows: KANSAS. *Douglas County*: Univ. Kansas Natural History Reservation, *Elaphe obsoleta,* September 10, 1952 (18 nymphs, reared DAC).

Genus *Walchia* Ewing

Walchia Ewing, 1931, Proc. U. S. Nat. Mus., vol. 80, p. 10, [type *Trombidium glabrum* Walch (not *Trombidium glabrum* Dugès) = *Walchia pinque* Gater] (*larva*); Wharton *et al.*, 1951, Jour. Parasit., vol. 37, p. 30 (*adult*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 91 (*postlarvae*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 161 (*adult*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, p. 1362 (*larva*).

Gahrliepia (*Walchia*), Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 393 (*nymph*).

Diagnosis (*nymph*).—(1) Eyes absent. (2) Precoxal plates of coxae I absent. (3) Body setae branched, not expanded, without compound branching; adjacent setae of similar lengths. (4) Claws on tarsus I undivided distally. (5) *Tarsus I with dorsoapical stump-like process.* (6) Cheliceral base not unusually elongated; blade shearlike. (7) Palpal trochanter not elongated. (8) *Hypostome short, blunt; with about twenty short apical nude or nearly nude setae.* (9) *Pharynx marked with a reticulate pattern.* (10) Tectum almost square, hyaline, margin with teeth; *without tectal seta.* (11) *Sensillary area wide;* mean ratio ASL/SB: 1.3. (12) Without branched body seta in sensillary area. (13) Sensilla straight, with branches.

Additional features (nymph).—(14) Body small (about 0.5 mm. long). (15) Sternum elongated-rectangular in shape, closed behind. (16) Tarsus I elongated. (17) *Articulating area of cheliceral base on posterior margin; posterior tip of cheliceral base elevated.* (18) Palpus stout, small; claw slightly elongated, rather straight; distal portion of tibia not unusually elongated; two accessory claws; tarsus with seven to nine branched setae and *one apical nude seta.* (19) Hypostome with about ten ventral branched setae. (20) Basis capituli of normal shape. (21) Crista a short narrow rod. (22) Sensillary area with basal plate of two well-separated halves; bulla rather large; carina absent; sensillary bases placed well lateral; anterior and posterior ridges present; lateral ridges present but less prominent than ridges medial to sensillary bases; apodeme small. (23) *Only two parascutal setae.*

Remarks.—One species of the genus, *Walchia americana,* is known from the United States. Ten or more species are known from the Asiatic-Pacific Region. Nymphs of four of these species have been described by Womersley (1952:285).

Womersley (1952:278) considered *Walchia, Schöngastiella* Hirst, and *Gateria* Ewing to be subgenera of *Gahrliepia* Oudemans. This opinion was based upon comparisons of both larvae and nymphs of members of these genera. Womersley's opinion may certainly be correct; the features mentioned in his descriptions of nymphs do not appear to indicate generic separation for these forms. I am persisting, however, in using the generic name *Walchia* (as did Loomis, 1956), at least until Womersley's more conservative approach can be substantiated.

While Womersley's descriptions are not adequate for close comparisons, it does appear that at least some of the species he describes will not key out to *Walchia* in my key. In the generic diagnoses for *Gahrliepia,* Womersley states that one epistomal seta (tectal seta) is present. However, this seta was clearly seen by him on only two of ten species, and was but indistinctly seen on two others. The tectal seta is definitely absent on both nymphs and adults of *Walchia americana,* and I have included this as a generic feature and used it in the key to genera, to separate *Walchia* from *Schoutedenichia.* If Womersley's descriptions are correct some additional feature must be found. The single pair of parascutal setae or the single apical nude seta of the palpal tarsus of *Walchia* possibly separate these two genera; unfortunately these features are not mentioned by Womersley.

Walchia americana Ewing

(Figs. 35, 84, 118, 119, 147, 188, 203, 235)

Walchia americana Ewing, 1942, Jour. Parasit., vol. 28, p. 491 (*larva*); Loomis, 1956, Univ. Kansas Sci. Bull., vol. 37, pp. 1363-1365 (*larva*).

Description of nymph.—Body: About 0.5 mm. long, rounded, color white. Setae short, stems thick at bases and abruptly tapered, with many short branches; posterior setae with tips of 2-3 tiny branches; posterior setae about 14 μ long. Sternum closed behind, elongated posteriorly, often with an indication of incipient longitudinal division; with about 8 setae. Tarsus I with small stumplike process projecting from apical dorsal margin. Measurements of tarsus I (means of 7 specimens); TL: 77.9 ± 1.945, TH: 46.7 ± 1.646, TL/TH: 1.67 ± 0.0606.

Gnathosoma: Cheliceral base of characteristic shape, punctate; blade shearlike, with about 10 small teeth. Cheliceral measurements (means of 10 specimens); BL: 56.3 ± 0.731, BH: 28.0 ± 0.4899, CL: 28.0 ± 0.648, BL/BH: 2.01 ± 0.0434, BL/CL: 2.01 ± 0.0456. Palpus with accessory claws long; tarsus with tarsala about 9 μ long, apical nude seta on inner surface. Setal counts (means of 10 specimens); femur: 4.95 ± 0.0879, genu: 7.4 ± 0.2082, tibia: range 3-4, tarsus: range 7-9.

Scutum: Sensillary area broadly transverse-oval; apodeme reduced; major posterior ridge running medial to sensillary bases; ridges anterior and posterior to sensillary bases weak; posterior ridge discontinuous, ends joined by small secondary ridge; bulla triangular, prominent; carina absent; sensilla with stems thickened but flexible, with short basal branches and longer branches on remainder of stems. Scutal measurements (means of 10 specimens); ASL: 45.1 ± 0.836, SB: 34.6 ± 0.7023, SENS: about 75, ASL/SB: 1.32 ± 0.0326.

Remarks.—In Womersley's (1952:280) key to species of *Gahrliepia, Walchia americana* will key out to *G. rustica,* from which it may be separated by the shorter posterior body setae (14 μ long in *americana,* 32 μ long in *rustica*).

Walchia americana was reared on four occasions and reached a complete generation on three of these occasions. The nymphs and adults were fed upon active stages of the collembolan, *Sinella curviseta.*

Specimens examined.—Total 21 nymphs, as follows: KANSAS. *Douglas County: Sciurus niger,* January 19, 1950 (2 nymphs, reared LJL); 2 mi. S Warden, *Sciurus niger,* November 28, 1949 (1 nymph,

reared LJL); 4½ mi. W, 3 mi. S Baldwin, *Sciurus niger*, November 28, 1951 (4 nymphs, reared DAC). *Jefferson County*: 10 mi. W Midland, November 14, 1953 (14 nymphs, reared RBL-DAC).

Additional Genera Known As Postlarvae

This section includes those genera which are known as postlarvae but for which no specimens were available for study. Most are included in the key to genera on characters given in descriptions by other authors. Many of these descriptions are brief; often they contain no indication of characters considered as generic in the present paper. Thus it is not possible to give full diagnoses for these genera. In the discussions, further features are indicated, usually by comparisons with better known genera.

SUBFAMILY TROMBICULINAE EWING

Genus *Ascoschöngastia* Ewing

Ascoschöngastia Ewing, 1946, Proc. Biol. Soc. Washington, vol. 59, p. 71 (type *Neoschöngastia malayensis* Gater) (*larva*).
Schöngastia (*Ascoschöngastia*), Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 384 (part.) (*nymph*).

Diagnostic features (nymph).—Apparently identical with *Euschöngastia.*

Remarks.—This genus is recognized by Wharton and Fuller (1952:71) for trombiculine species which as larvae have expanded sensilla and the PL setae off of the scutum. Five species are included. Womersley (1952:384) described the nymph of *A. malayensis* and concluded that it was not generically separable from those of species which he placed in *Schöngastia* (*Ascoschöngastia*) (= *Euschöngastia*). Womersley confirms in a footnote (*ibid*, p. 170) that *Euschöngastia* has priority over *Ascoschöngastia* and that this synonomy should obtain in his system.

The description of the nymph of *A. malayensis* as given by Womersley is not adequate for purposes of comparison. Therefore, I must follow Womersley in regarding *malayensis* as inseparable from nymphs of *Euschöngastia.*

Genus *Doloisia* Oudemans

Doloisia Oudemans, 1910, Ent. Ber. Amst., vol. 3, p. 87 (type *Doloisia synoti* Oudemans) (*larva*); Sasa, 1953, Japanese Jour. Exp. Med., vol. 23, p. 427 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 157 (*nymph*).

Diagnostic features (*nymph*).—(1) Eyes absent. (2) Precoxal plates absent. (8) Hypostome pointed, projecting, with about eight apical nude setae. (10) Tectum with teeth on margin. (11) Sensillary area broad, ratio ASL/SB: 0.7-1.2

Remarks.—The nymph of *Doloisia okabei* Sasa *et al.*, has been well described by Sasa (1953:427); the nymph of *D. oculicola* (Womersley) has been described by Womersley (1952:383); also, Audy (1954:157) has given some nymphal characters. The above diagnosis is based upon these publications. From Sasa's figures it appears that the palpal shape and the apical nude setae of the hypostome may be distinctive, as well.

Larvae of *Doloisia* have small characteristic scuta with expanded sensilla.

The general facies of nymphs as presented by authors is distinctive; the scutum of the nymph is somewhat similar to that of *Guntherana* but the species are abundantly distinct from that genus.

Genus *Gahrliepia* Oudemans

Typhlothrombium Oudemans, 1910, Ent. Ber. Amst., vol. 3, p. 105 (type *Typhlothrombium nanus* Oudemans) (*larva*) (not *Typhlothrombium* Berlese).

Gahrliepia Oudemans, 1912, Ent. Ber. Amst., vol. 3, p. 273 (type *Typhlothrombium nanus* Oudemans) (*larva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 393 (*nymph*).

Gateria Ewing, 1938, Jour. Washington Acad. Sci., vol. 28, p. 295 (type *Gahrliepia fletcheri* Gater) (*larva*).

Schöngastiella Hirst, 1915, Bull. Ent. Res., vol. 6, p. 188 (type *Schöngastiella bengalensis* Hirst) (*larva*).

Diagnostic features (*nymph*).—Same as those for *Walchia.*

Remarks.—Womersley (1952:279) synonomized the genera *Gateria, Schöngastiella,* and *Walchia* with *Gahrliepia,* on both larval and postlarval evidence. Some authors have been somewhat reluctant to accept this synonomy (see Audy 1954:161). Womersley described nymphs for species in all four genera, and on the basis of his descriptions, they are only specifically separable. I have used the generic name *Walchia* for *W. americana* and based my diagnosis of the nymph on that species. It is difficult to say how closely Womersley's species fit that diagnosis (see discussion of *Walchia*). Thus it is impossible for me to evaluate the *Gahrliepia* complex. Quite possibly Womersley's solution is the correct one.

Genus *Guntherana* Womersley and Heaslip

Guntherana Womersley and Heaslip, 1943, Trans. Roy. Soc. South Australia, vol. 67, p. 132 (type *Neoschöngastia kallipygos* Gunther) (*larva*); Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 83 (*larva, postlarva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 372 (*postlarva*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 156 (*larva, postlarva*).

Diagnostic features (*nymph*).—(2) Precoxal plates of coxae I present but not fused in midline to form longitudinally divided

sternum. (3) Body setae branched; adjacent setae of similar lengths. (11) Sensillary area wide, ratio ASL/SB: about 1.1.

Remarks.—These features are taken from Womersley (1952:372) and Audy (1954:156). Presumably they hold for the nymph and adult of *G. kallipygos,* and for *G. tindalei* and *G. translucens,* the latter known only as adults. Larvae of *Guntherana* are distinguished by the presence of caudal plates.

Relationships of the genus *Guntherana* are hard to define on the basis of the brief published descriptions. Nymphs appear to resemble those of *Trombicula*; however, the presence of precoxal plates indicates similarity with *Neoschöngastia* and the scutum resembles that of members of the *Euschöngastoides-Pseudoschöngastia-Walchia* group of genera. A detailed study of nymphs of the genus *Guntherana* would be of the greatest interest.

Genus *Heaslipia* Ewing

Trombiculoides Womersley and Heaslip, 1943, Trans. Roy. Soc. South Australia, vol. 67, p. 101 (type *Trombiculoides gateri* Womersley and Heaslip) (*larva*) (not *Trombiculoides* Jacot).

Heaslipia Ewing, 1944, Proc. Biol. Soc. Washington, vol. 57, p. 103 (type *Trombiculoides gateri* Womersley and Heaslip) (*larva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 422 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 149 (*nymph*).

Diagnostic features (*nymph*).—(10) Tectum large, an elongate triangular cone, not hyaline, margin without teeth or serrations. Otherwise similar to *Euschöngastia.*

Remarks.—This diagnosis is after Womersley (1952:422) and Audy (1954:149) based upon *Heaslipia gateri.* Quite possibly the conelike tectum will not distinguish nymphs of *Heaslipia* from nymphs of some *Euschöngastia.* Larvae are similar to those of *Trombicula* but have additional scutal setae. The genus is monotypic.

Genus *Ipotrombicula* Womersley

Ipotrombicula Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 323 (type *Trombicula elegans* Womersley) (*adult only*).

Diagnostic feature (*adult*).—(12) With branched body seta in sensillary area.

Remarks.—This genus is monotypic for *I. elegans,* known only as adult. Except for the key character of the possession of a branched seta in the sensillary area, this species would probably be placed in *Trombicula,* subgenus *Eutrombicula;* it possesses eyes in typical *Eutrombicula* position. Indeed this may be its proper place.

Genus *Schöngastia* Oudemans

Schöngastia Oudemans, 1910, Ent. Ber. Amst., vol. 3, p. 87 (type *Thrombidium vandersandei* Oudemans) (*larva*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 376 (*nymph*); Audy, 1954, Stud. Inst. Med. Res. Fed. Malaya, no. 26, p. 150 (*nymph*).

Diagnostic features (*nymph*).—(2) Precoxal plates of coxae I present but not fused in midline to form longitudinally divided sternum. (3) Adjacent body setae of similar lengths. (11) Sensillary area triangular; ratio ASL/SB: about 2.0.

Remarks.—Nymphs of three species of *Schöngastia* were described by Womersley (1952:381-387). Womersley does not mention the precoxal plates, but Audy (1954:150) says that these are present. The nymphs, as described by Womersley, show no other features clearly separating them from *Trombicula.*

Genus *Schoutedenichia* Jadin and Vercammen-Grandjean

Schoutedenichia Jadin and Vercammen-Grandjean, 1954, Ann. Mus. Congo Tervuren, Zool., vol. 1, p. 195 (type *Schoutedenichia fulleri* Jadin and Vercammen-Grandjean) (*larva*).

Diagnostic features (*nymph*).—(2) Precoxal plates of coxae I absent. (5) Tarsus I with dorsoapical stumplike process. (10) Tectum with a single tectal seta.

Remarks.—These features are taken from descriptions by Jadin and Vercammen-Grandjean (1954:287, 289) of nymphs of *S. penetrans* and *S. pirloti.* In combination these features separate nymphs of *Schoutedenichia* from those of other genera. From the illustrations by Jadin and Vercammen-Grandjean it may be seen that the genus has some features of the *Euschöngastoides-Pseudoschöngastia-Walchia* group of genera, including the scutal shape, the blunt hypostome with about twenty short apical setae, and the features of palpal setation. As previously noted, *Schoutedenichia* is very probably closely related to this group of genera.

Genus *Speotrombicula* Ewing

Speotrombicula Ewing, 1946, Jour. Parasit., vol. 32, p. 437 (type *Trombicula trifurca* Ewing) (*adult only*); Wharton and Fuller, Mem. Ent. Soc. Washington, no. 4, p. 90 (*adult*); Womersley, 1952, Rec. South Australian Mus., vol. 10, p. 324 (*adult*).

Diagnostic feature (*adult*).—(4) Claws on tarsus I trifurcate distally.

Remarks.—*Speotrombicula* is monotypic for *S. trifurca,* known only as adult. Judging from Ewing's (1933:3) description the species is a *Trombicula* except for the key character of the divided claws. However, this description is brief.

Genus *Walchiella* Fuller

Walchiella Fuller *in* Wharton and Fuller, 1952, Mem. Ent. Soc. Washington, no. 4, p. 95 (type *Trombicula oudemansi* Walch) (*larva*).

Diagnostic features (*nymph*).—None.

Remarks.—Womersley (1952:380) has described the nymph of *Walchiella oudemansi*, which he included in *Schöngastia* (*Schöngastia*). His description indicates no features which separate the nymph from those of *Trombicula*. A possible useful character is present in the posterior body setae, which have a subterminal branch that is unusually long (as long as the seta itself). Considering the variation in form of the posterior body setae, as observed in *Euschöngastia* and *Trombicula*, this character does not seem to have generic significance.

Walchiella is monotypic for *W. oudemansi*. Larvae have six segments in legs II and III, expanded sensilla, and five scutal setae.

COMPARISON OF SYSTEMS OF CLASSIFICATION

Workers are in general agreement concerning the classification based primarily on larvae. In the main similar generic levels are given in recent papers, but there is less agreement on generic alignment in subfamilies. Audy (1954:134-135) presents in tabular form his own generic arrangement, that of Wharton and Fuller (1952), and that of Womersley (1952). Although these systems are divergent it may be seen that there is general agreement as to the status of most of the genera.

These systems of classification are based primarily on the larval stage but taxonomic characters of known postlarvae were quite evidently considered. The classification in the present paper is based upon both larval and postlarval stages, perhaps with the latter stages given more than the usual weight.

Concerning the species level, there appears to be no reason for insisting that species be distinct from one another in both larval and postlarval stages. The majority of the species studied are distinct in both stages, although some (for example, species of *Pseudoschöngastia*) are more readily separated as larvae while others (species of *Neoschöngastia*) are more readily separated as nymphs. An area of greater interest in the comparison of systems is at the more arbitrary generic and higher levels, where weighting of characters becomes important.

With the two classifications there are four types of generic categories as regards distinctiveness; these are (1) genera distinct, *i. e.*,

recognizable by a character or combination of characters, in both the larval and postlarval stages, (2) genera distinct in the larval stage but not recognizable in postlarval stages, (3) genera distinct in postlarval stages but not recognizable in the larval stage, and (4) genera distinct in neither stage but recognizable by some other criterion. Examples of the first three of these points are known. These considerations, of course, apply to subgenera, subfamilies, and other supraspecific categories as well as to genera.

Most of the subgenera and genera were found to be recognizable on morphological characters of both larval and postlarval stages. Members of the subgenus *Neotrombicula* are recognizable on larval characters but no postlarval characters were found for this group. Species in the genus *Blankaartia* and perhaps the subgenus *Leptotrombidium* are difficult to recognize as larvae but are readily recognized on postlarval characters. The genus *Euschöngastoides*, as recognized in the present paper, contains two species clearly distinct as nymphs but as larvae they are members of different genera. With these few exceptions, evidence of the nymphal stage corroborates the classification based on larvae.

Of the exceptions noted above, *Blankaartia* and *Neotrombicula* are not serious discrepancies; in both cases relationships are clear in larval and postlarval stages. In other genera, also, the degree of distinctiveness is not the same in the two phases of the life history. Some as yet undetected character may serve to separate nymphs of species of *Neotrombicula* from those of the typical subgenus. Further studies of the larvae of *Blankaartia* may make the identification of larvae of that genus easier. In these cases evidence from postlarval stages does not show that relationships are other than those indicated in the larval stage; the matter is one of relative distinctiveness.

A question posed by these exceptional cases concerns the status of genera and subgenera; namely, should a genus (or subgenus) necessarily be recognizable in both larval and postlarval stages in order to be acceptable? Womersley, in a revision of trombiculids, considered postlarval evidence and concluded (1952:9), "Such a revision shows that many of the larval genera which have been proposed cannot be separated in the nymphal or adult stages, should not be used except perhaps for convenience, as subgenera based on larval features only." Audy, in consideration of this problem writes (1954:127), ". . . rigid ideas on the employment of either larval or adult characteristics are to be deplored." "Certainly,

species and subgenera based entirely on morphological larval characters may be fully acceptable though the free extension of this to genera (and even to subfamilies, as has been done) is debatable in particular instances." The present writer is more in agreement with Audy than with Womersley. It does not seem possible to draw a hard and fast rule for cases of relative distinctiveness. The creation of genera indistinguishable in one phase of the life history poses practical problems rather than philosophical ones.

The genus *Euschöngastoides* poses a more difficult problem. As explained in the taxonomic section of this paper, the two species of *Euschöngastoides,* as larvae, key out to different genera, *Trombicula* and *Euschöngastia.* Except for the key character, the nature of the sensillum, the two larvae are very similar. As nymphs, the two species are similar to each other but differ markedly from *Trombicula* and *Euschöngastia.* The relationships of the two species (on nymphal evidence) appear to be with *Pseudoschöngastia* and *Walchia.* If the relationships as indicated by the nymphs are correct, then the erroneous placement of the larvae was due to the rigid use of a single key character in separating *Trombicula* and *Euschöngastia.* If the relationships are correct on larval evidence, the similarity of the nymphs (and of other larval characters) must be assumed to be due to parallelism. The writer feels that the nymphal evidence is the more convincing and thus gives generic status to *Euschöngastoides.*

Undoubtedly other similar cases will arise. If these are judged on their individual merits, without undue weighting of characters of any stage, the result should be a more natural system of classification. The postlarval evidence should be considered as additional knowledge concerning the relationships of the organisms.

The remaining genera are distinct as such in both phases of the life history. Both *Euschöngastia* and *Speleocola* seem closely related to *Trombicula* in both stages. In *Cheladonta* and *Neoschöngastia,* the larvae are similar to those of *Euschöngastia,* but postlarvae of these two genera are quite distinctive. *Pseudoschöngastia* and *Walchia* are similar to one another as nymphs, more so than as larvae.

RUDIMENTS OF PHYLOGENY

As previously stated, this study is restricted mainly to species in North America, and the available nymphs represent but a fraction of the species known from this continent. Some genera are known only as larvae. Under these conditions it would not be realistic to attempt to construct a detailed phylogeny of the group. However,

it seems possible that an outline of the evolutionary development of the group might be proposed, since at least the major genera of trombiculids are known as nymphs. The following ideas, therefore, are offered as the writer's opinions; the evidence for them is meager in most cases and further work will undoubtedly indicate modifications. The genera not studied by the writer are not included in this discussion; to do so would be compounding speculation.

The origin of trombiculids is almost certainly in the family Trombidiidae. The distinction between the two families is not clear-cut. Certain genera, such as *Neotrombidium*, could be placed in either family on morphological grounds (Borland, 1956:30). From evidence available at present, it appears that trombiculids are closely related to members of the trombidiid subfamily Microtrombidiinae, which itself is heterogeneous. Trombiculids are not far removed from the primitive trombidiids (*Johnstoniana* and relatives).

By analogy with the trombidiids, certain characters of some trombiculid nymphs are deduced to be primitive. The primitive condition of the gnathosoma appears to be as follows: Hypostome pointed, projecting, with about eight apical nude setae. Cheliceral base elongated, with posterior tip depressed; cheliceral blade shearlike, with teeth. Palpus large, with numerous setae, with claw and two accessory claws, and tarsus with several apical nude setae. Primitive features of the scutum include: Tectum rounded, margin smooth; with two tectal setae. Crista rodlike, long. Sensillary area simple, circular or oval shaped, with few or no ridges; sensilla without branches; posterior apodeme rodlike. Other primitive characters appear to be the presence of eyes anterior to the sensillary area, the absence of a closed sternum, and a simple circular anus. While unmodified body setae are possibly primitive, so many genera in the family Trombidiidae have highly modified body setae that it seems unsafe to make this generalization for trombiculids. The strongly constricted body of most trombiculid nymphs is seemingly specialized, but again body shapes vary within the family Trombidiidae and there is little to suggest what shape is primitive for the trombiculids.

The specialized conditions for these characters are the alternative ones given in the section on morphology. To repeat them here seems unnecessary. Many of the specialized states are mentioned in the following discussion.

It is more difficult to suggest primitive characters for the larval stage. Few trombidiid larvae are known; most of the described forms belong to the more highly developed trombidiids. The

gnathosomal elements are particularly difficult, since both the chelicerae blade and the palpus seem specialized in larvae of both families. For the scutum a rectangular shape, an anteromedian projection, two anteromedian setae, unexpanded sensilla, and four marginal setae seem primitive. Possibly, undivided femora of the legs is a primitive character but this conclusion is based entirely on comparisons within the family.

To return to the nymphal characters, it is possible to follow in a general way some features of the evolutionary development of two structural areas, the gnathosoma and the scutum. The characters listed above as primitive are found among the genera of the subfamily Leeuwenhoekiinae. Although there is some deviation in hypostomal shape, shape of cheliceral elements, and presence of eyes, the general facies for these areas in the Leeuwenhoekiinae is primitive. The gnathosomal elements show some modifications in most genera of Trombiculinae. Except for reduced palpal setation and slight cheliceral modification in some species, the genera *Euschöngastia, Speleocola,* and *Trombicula* have a primitive condition of gnathosomal elements. *Blankaartia* differs only in the possession of additional accessory claws on the palpus in some species, a situation common in the trombidiids. Greater modification is seen in *Neoschöngastia,* where palpal claws are elongated, chelicerae shortened, and hypostome blunt; *Cheladonta* has all gnathosomal elements elongated. Finally, the genera *Euschöngastoides, Pseudoschöngastia,* and *Walchia* have distinctive chelicerae and markedly modified hypostoma.

Scutal elements are also modified in the subfamily Trombiculinae. These are discussed in detail in the section on morphology. Most noticeable specializations are the reduction in number of tectal setae, shortening and thickening (in some) of the crista, development of ridges and other structures in the sensillary area, modification or reduction of the posterior apodeme, and modification of the sensilla. The genus *Blankaartia,* aside from the possession of a single tectal seta and slight development of the sensillary area, has an essentially primitive scutum. Development of the sensillary area seems to proceed along two different lines among the remaining genera. The sensillary areas of the genera *Euschöngastoides, Pseudoschöngastia,* and *Walchia* are quite broadened. The remaining genera have less broadened but seemingly more complicated sensillary areas; those of *Cheladonta* and *Neoschöngastia* each have distinctive features not shared by *Euschöngastia, Trombicula,* and *Speleocola.*

From these considerations it is possible to divide the genera into three levels of increasing specialization. The first level, the more primitive state, includes genera of the subfamily Leeuwenhoekiinae. The second level, an intermediate state, includes the genera *Blankaartia, Euschöngastia, Speleocola,* and *Trombicula.* The third level, the most specialized state, includes the genera *Cheladonta, Neoschöngastia, Euschöngastoides, Pseudoschöngastia,* and *Walchia.* It seems likely that these levels represent an evolutionary sequence.

Unfortunately it is not possible to consider more detailed relationships within the Leeuwenhoekiinae. Among the five genera only eight species are known as nymphs and these appear to be but slightly modified. Speculation as to their relationships would be fruitless. Possibly, also, the habit of parasitism on vertebrates has arisen more than once and a realistic evaluation must consider the very similar forms in the Trombidiidae.

Blankaartia is the least modified of the intermediate genera and might be considered halfway between the primitive forms and the other intermediate ones. The other intermediate genera, *Trombicula, Euschöngastia,* and *Speleocola* appear closely related. The genera *Euschöngastoides, Pseudoschöngastia* and *Walchia* are similar and quite possibly represent a valid unit. While they are unhesitatingly considered specialized, it is difficult to avoid the impression that in these genera the sensillary area of the scutum is less modified than is that of the genera of the intermediate level. It might be more reasonable to suggest that these three genera are separately derived from the primitive forms, or at least that they are an early branch from the intermediate group of genera. The other specialized genera, *Cheladonta* and *Neoschöngastia* seem distinctive.

Features of the larval stage essentially confirm this general sequence. The subfamily Leeuwenhoekiinae again clearly represents the primitive state. A close relationship between larvae of genera of the intermediate state appears. The specialized genera *Cheladonta, Neoschöngastia, Euschöngastoides,* and perhaps *Pseudoschöngastia* seem related to the intermediate genus *Euschöngastia* in features of scutal shape and nature of the sensilla. It has been previously noted, however, that the character of the sensilla (expanded vs. flagelliform) which separates the genera *Euschöngastia* and *Trombicula* has led to strange relationships.

While larva and postlarva are adapted to different sorts of existence, the divergence in form is not extreme when compared to other animals with divergent phases of the life history (the holometabolous insects, for instance). Although obviously modified,

the scutal and gnathosomal elements likely perform identical or similar functions in the two stages. In these mites a possible evolutionary mechanism is the transfer of a structural modification from one stage to another stage. The sensillum of the larva of *Euschöngastoides hoplai* seems identical with the sensillum of the nymph of that species; it is possible that in this case the larva has acquired the sensillum of the nymph, since other similar larvae have expanded sensilla. Sensilla may serve different purposes in the two phases of the life history but it is possible that adaptive modifications in the nymph could be of advantage to the larva. No evidence of other such transfers was noted. It is possible, however, that the transfer of such preformed structures from one stage to another differently adapted one could play an important role in the evolution of these mites.

As more postlarvae are described these suggestions as to phylogeny will doubtless require modification. A productive study would be the ecology and functional physiology of these mites, to provide an indication of the specific uses of the structures here considered and thus a better understanding of the selective forces producing them.

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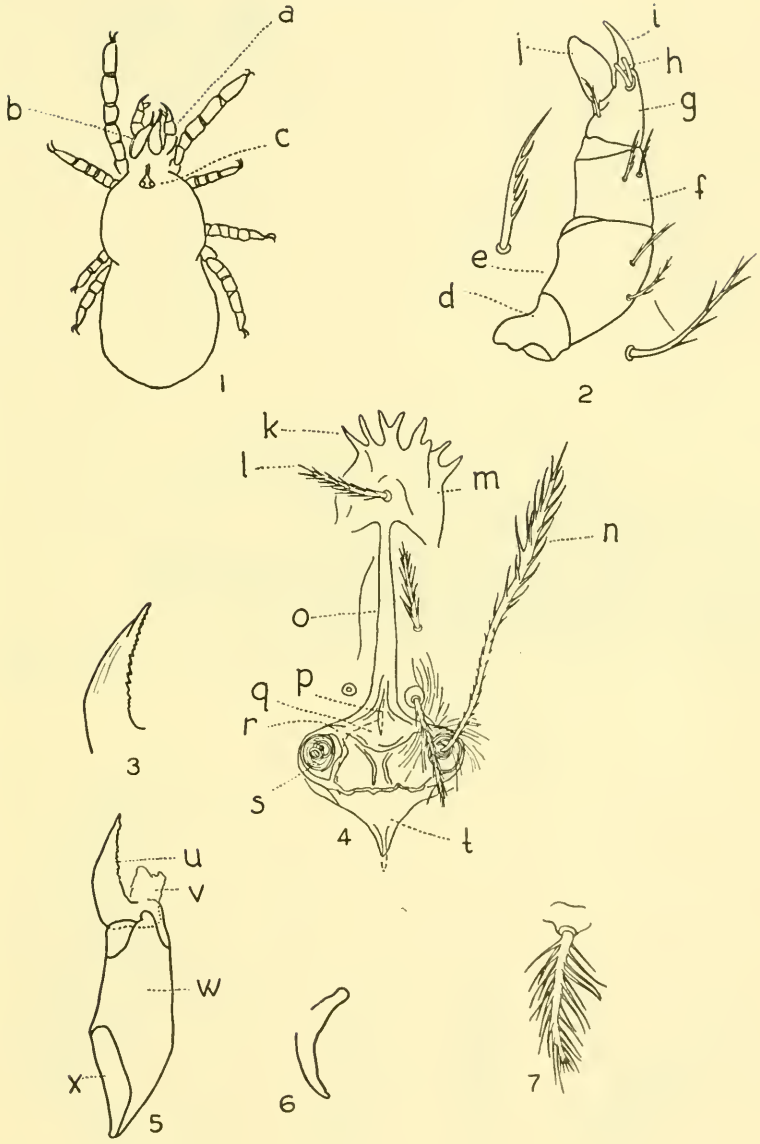
EXPLANATION OF FIGURES 1-7

Trombicula trisetica, nymph

Fig. 1. Body shape, dorsal view.
Fig. 2. Palpus, medial view.
Fig. 3. Cheliceral blade, lateral view.
Fig. 4. Scutum, dorsal view.
Fig. 5. Chelicera, lateral view.
Fig. 6. Cheliceral apodeme, lateral view.
Fig. 7. Posterior dorsal body seta.

a. palpus
b. chelicera
c. scutum
d. trochanter
e. femur
f. genu
g. tibia
h. accessory claws
i. claw
j. tarsus
k. teeth of tectal margin
l. tectal seta
m. tectum
n. sensillum
o. crista
p. carina
q. bulla
r. basal plate
s. sensillary base
t. posterior apodeme
u. cheliceral blade
v. pseudochela
w. cheliceral base
x. area of articulation of cheliceral base with basis capituli

FIGURES 1-7



EXPLANATION OF FIGURES 8-15

Features of Nymphs. (Not to same scale.)

Fig. 8. *Euschöngastoides loomisi,* hypostome.
Fig. 9. *Trombicula montanensis,* hypostome.
Fig. 10. *Cheladonta ouachitensis,* hypostome (lateral view).
Fig. 11. *Neoschöngastia brennani,* tip of hypostome.
Fig. 12. *Trombicula montanensis,* genitalia.
Figs. 13-15. *Trombicula splendens,* variations in branching of genital setae.

FIGURES 8-15

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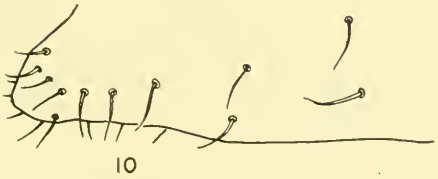
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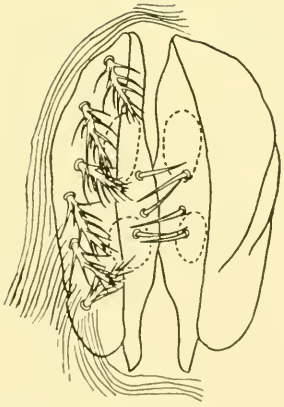
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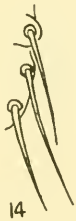
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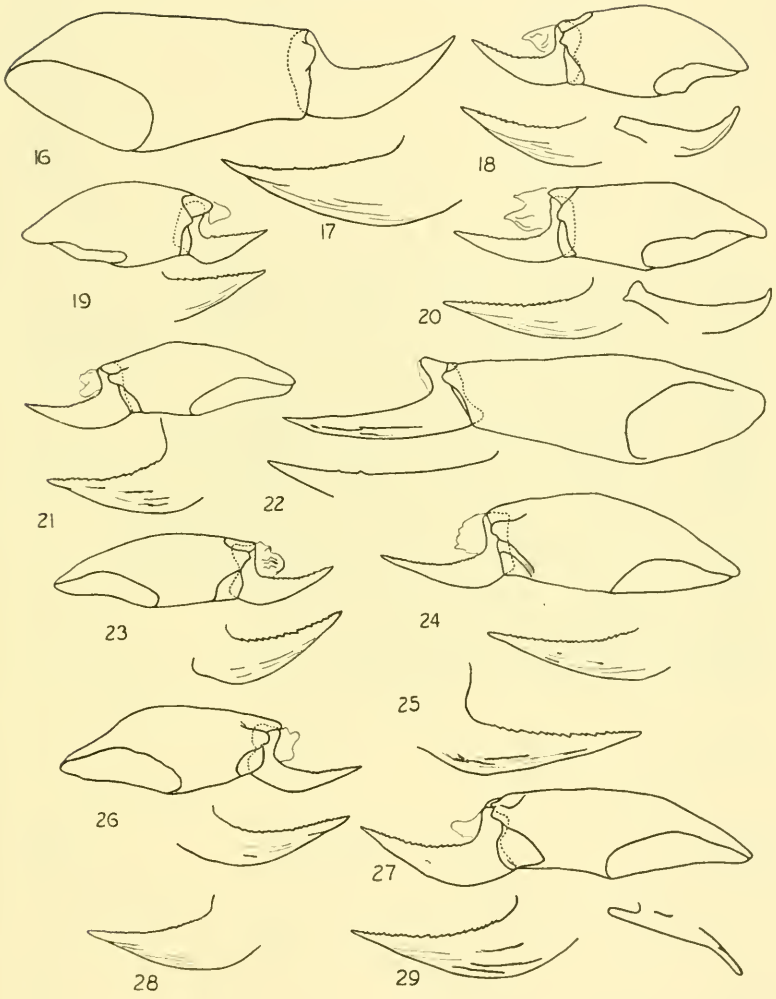
15

EXPLANATION OF FIGURES 16-29

Chelicerae of Nymphs. (Not to same scale.)

Fig. 16. *Chatia setosa,* chelicera.
Fig. 17. *Chatia setosa,* cheliceral blade.
Fig. 18. *Leeuwenhoekia americana,* chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 19. *Hannemania multifemorala,* chelicera and cheliceral blade.
Fig. 20. *H. eltoni,* chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 21. *Trombicula alfreddugèsi,* chelicera and cheliceral blade.
Fig. 22. *Blankaartia alleei,* chelicera and cheliceral blade.
Fig. 23. *Trombicula belkini,* chelicera and cheliceral blade.
Fig. 24. *T. splendens,* chelicera and cheliceral blade.
Fig. 25. *T. lipovskyana,* cheliceral blade.
Fig. 26. *Euschöngastia jonesi,* chelicera and cheliceral blade.
Fig. 27. *E. setosa,* chelicera and cheliceral apodeme.
Fig. 28. *E. pipistrelli,* cheliceral blade.
Fig. 29. *E. setosa,* cheliceral blade.

FIGURES 16-29

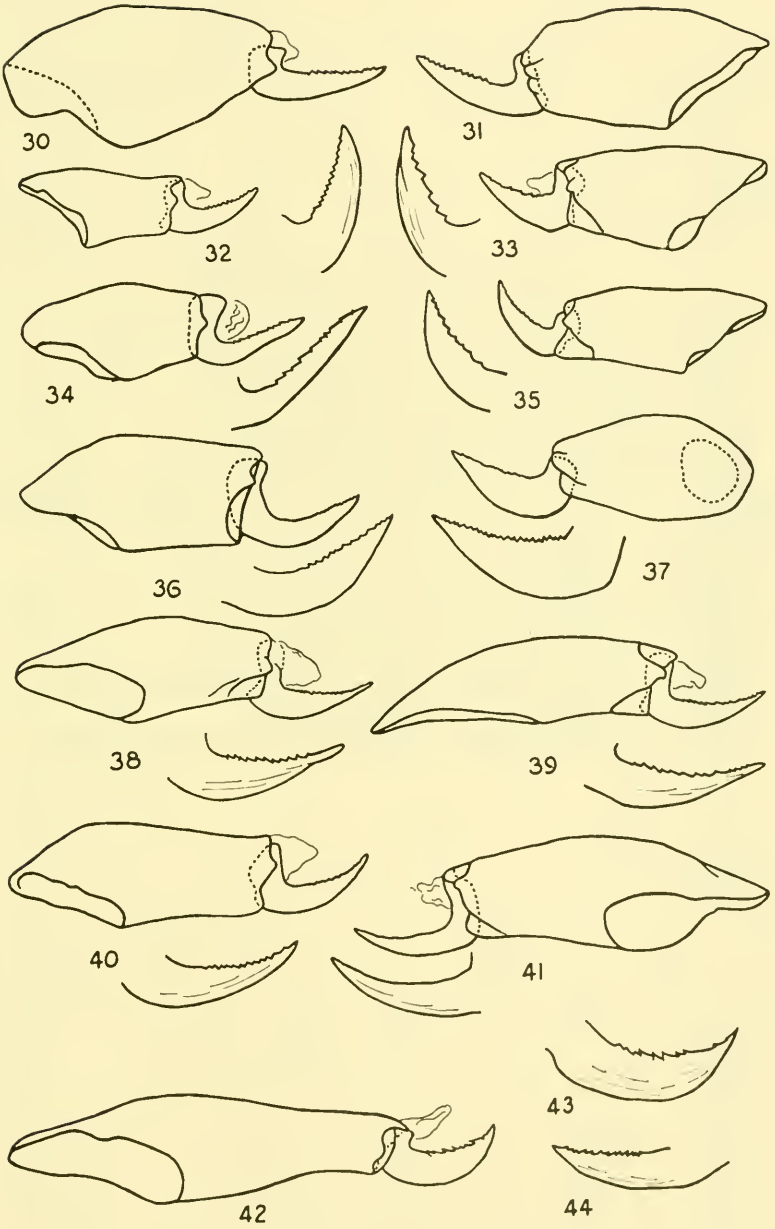


EXPLANATION OF FIGURES 30-44

Chelicerae of Nymphs. (To same scale except where indicated.)

Fig. 30. *Euschöngastoides loomisi,* chelicera (not to scale).
Fig. 31. *E. hoplai,* chelicera (not to scale).
Fig. 32. *Pseudoschöngastia hungerfordi,* chelicera and cheliceral blade.
Fig. 33. *P. farneri,* chelicera and cheliceral blade.
Fig. 34. *Acomatacarus plumosus,* chelicera and cheliceral blade.
Fig. 35. *Walchia americana,* chelicera and cheliceral blade.
Fig. 36. *Whartonia senase,* chelicera and cheliceral blade.
Fig. 37. *Acomatacarus arizonensis,* chelicera and cheliceral blade.
Fig. 38. *Trombicula merrihewi,* chelicera and cheliceral blade.
Fig. 39. *Speleocola tadaridae,* chelicera and cheliceral blade.
Fig. 40. *Neoschöngastia americana,* chelicera and cheliceral blade.
Fig. 41. *N. brennani,* chelicera and cheliceral blade.
Fig. 42. *Cheladonta micheneri,* chelicera.
Fig. 43. *C. micheneri,* cheliceral blade.
Fig. 44. *C. ouachitensis,* cheliceral blade.

FIGURES 30-44



EXPLANATION OF FIGURES 45-59

Chelicerae of Nymphs. (To same scale.)

Fig. 45. *Euschöngastia trigenuala,* chelicera and cheliceral blade.
Fig. 46. *E. criceticola,* chelicera and cheliceral blade.
Fig. 47. *E. pipistrelli,* chelicera and cheliceral blade.
Fig. 48. *E. peromysci,* chelicera and cheliceral blade.
Fig. 49. *E. diversa,* chelicera and cheliceral blade.
Fig. 50. *E. cynomyicola,* chelicera and cheliceral blade.
Fig. 51. *Trombicula whartoni,* chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 52. *T. autumnalis,* chelicera and cheliceral blade.
Fig. 53. *T. sylvilagi,* chelicera and cheliceral blade.
Fig. 54. *T. montanensis,* chelicera and cheliceral blade.
Fig. 55. *T. myotis,* chelicera and cheliceral blade.
Fig. 56. *T. kansasensis,* chelicera and cheliceral blade.
Fig. 57. *T. gurneyi,* chelicera, cheliceral blade, and cheliceral apodeme.
Fig. 58. *T. ornata,* chelicera and cheliceral blade.
Fig. 59. *T. kardosi,* chelicera, cheliceral blade and cheliceral apodeme.

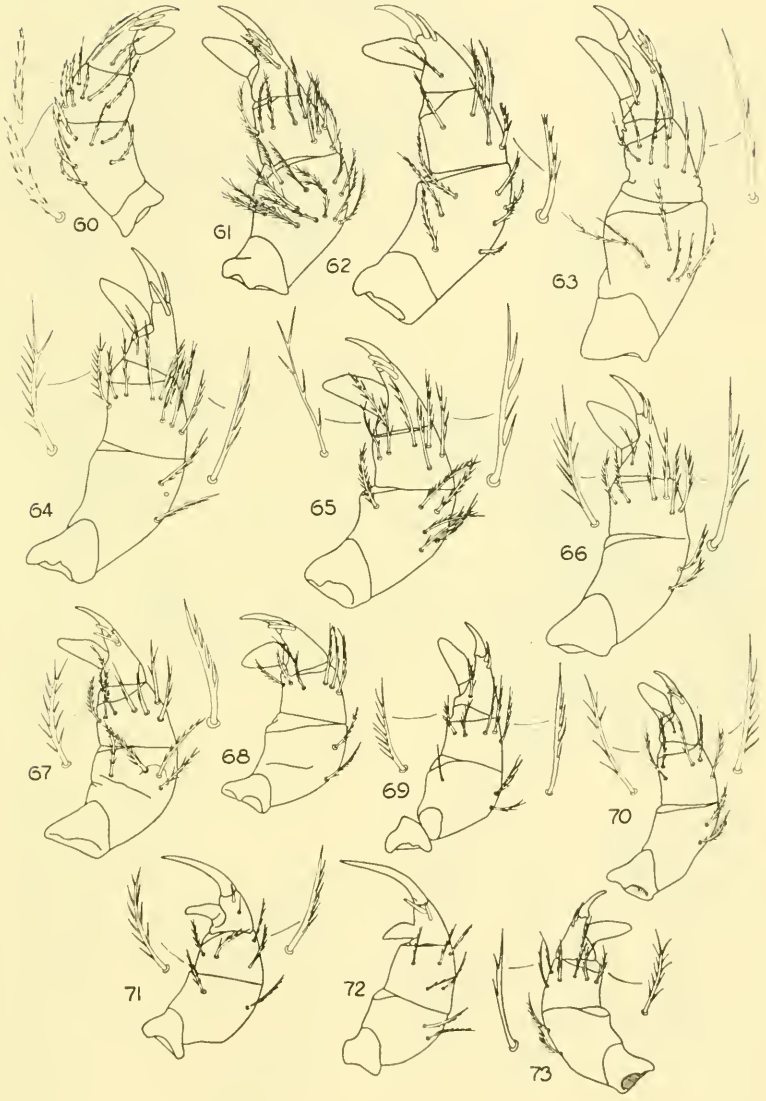
FIGURES 45-59

EXPLANATION OF FIGURES 60-73

Medial Views of Palpi of Nymphs.
(To same scale except where indicated.)

Fig. 60. *Whartonia senase.*
Fig. 61. *Hannemania eltoni* (not to scale).
Fig. 62. *Leeuwenhoekia americana.*
Fig. 63. *Blankaartia alleei* (not to scale).
Fig. 64. *Euschöngastia jonesi.*
Fig. 65. *E. setosa.*
Fig. 66. *E. peromysci.*
Fig. 67. *E. cynomyicola.*
Fig. 68. *E. trigenuala.*
Fig. 69. *Trombicula gurneyi.*
Fig. 70. *Euschöngastia cricticola.*
Fig. 71. *Neoschöngastia americana.*
Fig. 72. *N. brennani.*
Fig. 73. *Trombicula montanensis.*

FIGURES 60-73



EXPLANATION OF FIGURES 74-83

Medial Views of Palpi of Nymphs. (To same scale.)

Fig. 74. *Trombicula alfreddugèsi.*
Fig. 75. *T. splendens.*
Fig. 76. *T. lipovskyana.*
Fig. 77. *T. kansasensis.*
Fig. 78. *T. kardosi.*
Fig. 79. *T. belkini.*
Fig. 80. *T. whartoni* (includes apical nude setae on tarsus).
Fig. 81. *T. myotis.*
Fig. 82. *T. autumnalis.*
Fig. 83. *T. lipovskyi.*

FIGURES 74-83

EXPLANATION OF FIGURES 84-91

Medial Views of Palpi of Nymphs. (To same scale.)

Fig. 84. *Walchia americana.*
Fig. 85. *Cheladonta micheneri.*
Fig. 86. *Speleocola tadaridae.*
Fig. 87. *Euschöngastoides hoplai.*
Fig. 88. *Acomatacarus plumosus* (including dorsal genual, dorsal femoral, and lateral femoral seta).
Fig. 89. *Trombicula merrihewi.*
Fig. 90. *Pseudoschöngastia farneri.*
Fig. 91. *P. hungerfordi.*

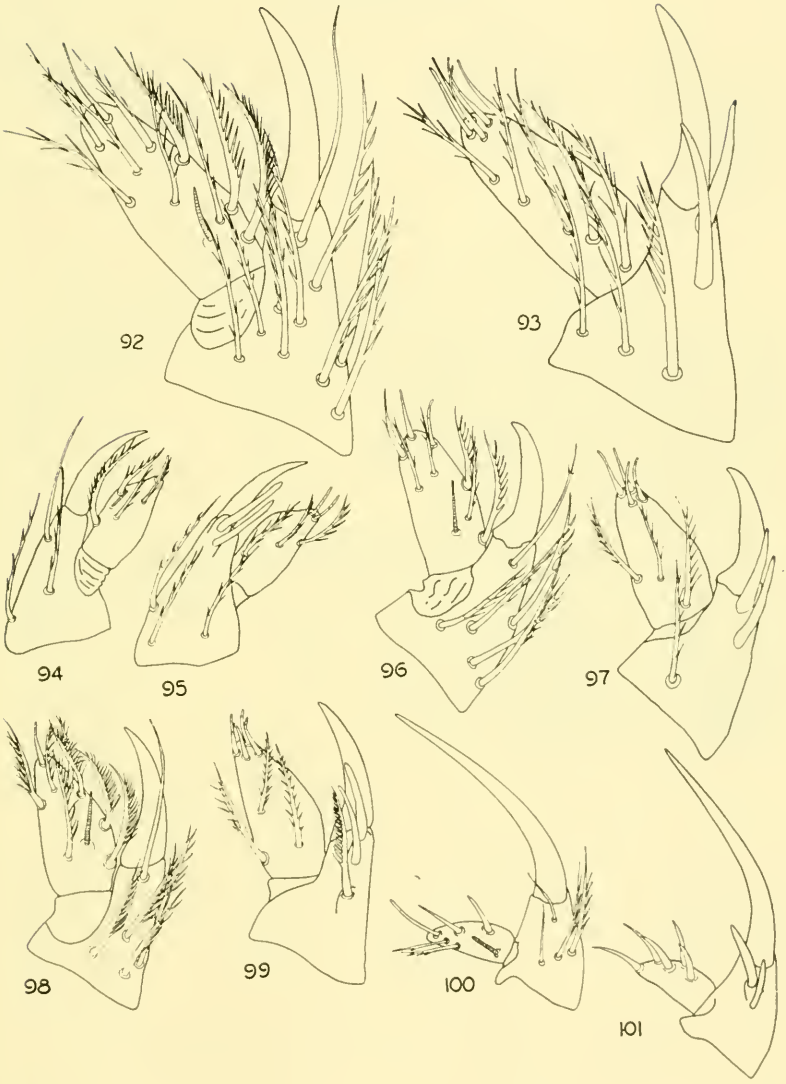
FIGURES 84-91

EXPLANATION OF FIGURES 92-101

Palpal Tibiotarsi of Nymphs. (To same scale.)

Fig. 92. *Chatia setosa,* lateral view.
Fig. 93. *C. setosa,* medial view.
Fig. 94. *Whartonia senase,* lateral view.
Fig. 95. *W. senase,* medial view.
Fig. 96. *Leeuwenhoekia americana,* lateral view.
Fig. 97. *L. americana,* medial view.
Fig. 98. *Hannemania eltoni,* lateral view.
Fig. 99. *H. eltoni,* medial view.
Fig. 100. *Neoschöngastia brennani,* lateral view.
Fig. 101. *N. brennani,* medial view.

FIGURES 92-101



EXPLANATION OF FIGURES 102-117

Palpal Tibiotarsi of Nymphs. (To same scale.)

Fig. 102. *Euschöngastia setosa,* lateral view.
Fig. 103. *E. setosa,* medial view.
Fig. 104. *E. peromysci,* lateral view.
Fig. 105. *E. peromysci,* medial view.
Fig. 106. *Trombicula myotis,* lateral view.
Fig. 107. *T. myotis,* medial view.
Fig. 108. *E. jonesi,* lateral view.
Fig. 109. *E. jonesi,* medial view.
Fig. 110. *Trombicula alfreddugèsi,* lateral view.
Fig. 111. *T. alfreddugèsi,* medial view.
Fig. 112. *T. gurneyi,* lateral view.
Fig. 113. *T. gurneyi,* medial view.
Fig. 114. *T. kansasensis,* lateral view.
Fig. 115. *T. kansasensis,* medial view.
Fig. 116. *T. lipovskyi,* lateral view.
Fig. 117. *T. lipovskyi,* medial view.

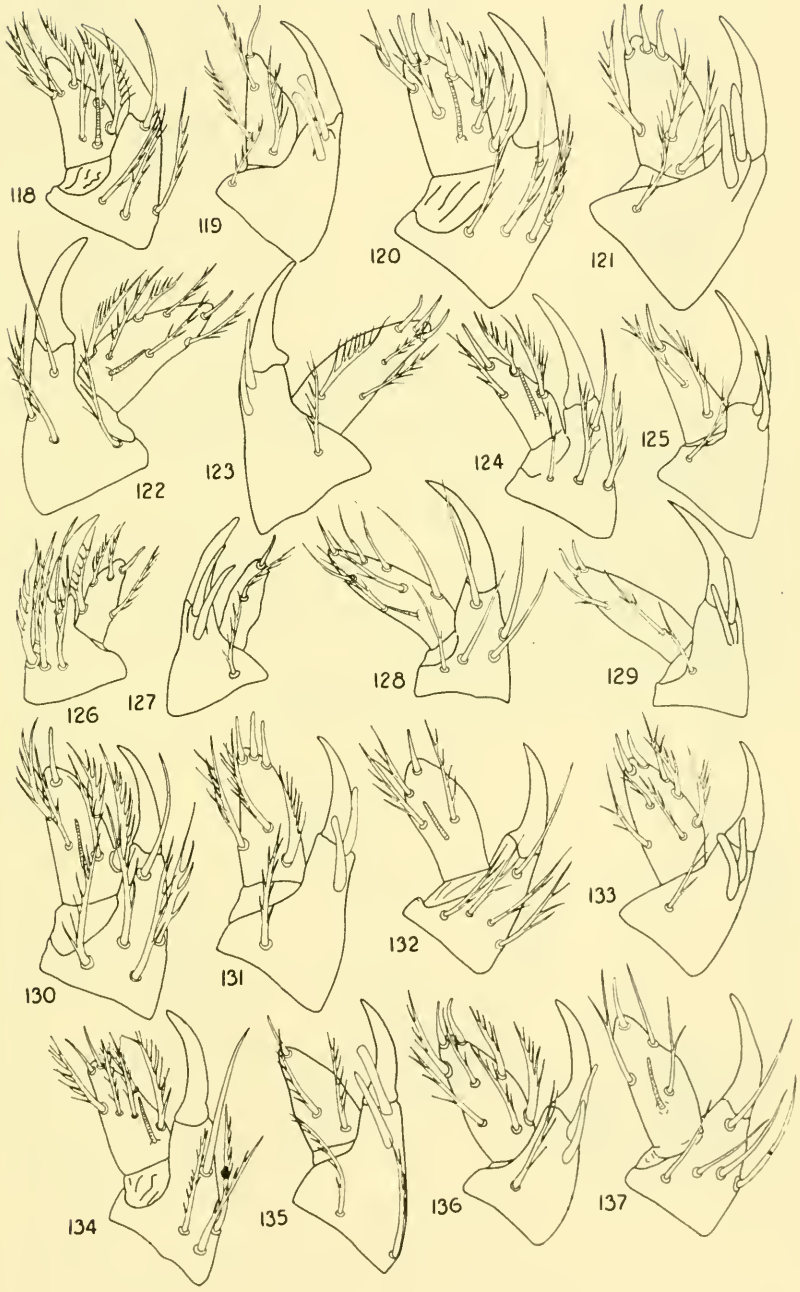
FIGURES 102-117

EXPLANATION OF FIGURES 118-137

Palpal Tibiotarsi of Nymphs. (To same scale.)

Fig. 118. *Walchia americana,* lateral view.
Fig. 119. *W. americana,* medial view.
Fig. 120. *Euschöngastia trigenuala,* lateral view.
Fig. 121. *E. trigenuala,* medial view.
Fig. 122. *Trombicula montanensis,* lateral view.
Fig. 123. *T. montanensis,* medial view.
Fig. 124. *Pseudoschöngastia farneri,* lateral view.
Fig. 125. *P. farneri,* medial view.
Fig. 126. *Euschöngastoides hoplai,* lateral view.
Fig. 127. *E. hoplai,* medial view.
Fig. 128. *Speleocola tadaridae,* lateral view.
Fig. 129. *S. tadaridae,* medial view.
Fig. 130. *Euschöngastia criceticola,* lateral view.
Fig. 131. *E. criceticola,* medial view.
Fig. 132. *Trombicula crossleyi,* lateral view.
Fig. 133. *T. crossleyi,* medial view.
Fig. 134. *Acomatacarus plumosus,* lateral view.
Fig. 135. *A. plumosus,* medial view.
Fig. 136. *Trombicula merrihewi,* lateral view.
Fig. 137. *T. merrihewi,* medial view.

FIGURES 118-137



Explanation of Figures 138-147

Scuta of Nymphs. (To same scale except where indicated.)

Fig. 138. *Acomatacarus plumosus.*
Fig. 139. *Hannemania eltoni.*
Fig. 140. *Leeuwenhoekia americana.*
Fig. 141. *Chatia setosa.*
Fig. 142. *Acomatacarus arizonensis* (not to same scale).
Fig. 143. *Whartonia senase.*
Fig. 144. *Pseudoschöngastia hungerfordi* (sensillum).
Fig. 145. *P. farneri* (not to same scale).
Fig. 146. *Euschöngastoides hoplai.*
Fig. 147. *Walchia americana* (not to same scale).

FIGURES 138-147

Explanation of Figures 148-156

Scuta of Nymphs. (To same scale except where indicated.)

Fig. 148. *Blankaartia velascoi* (not to same scale).
Fig. 149. *Neoschöngastia brennani.*
Fig. 150. *Euschöngastia criceticola.*
Fig. 151. *E. trigenuala.*
Fig. 152. *E. peromysci.*
Fig. 153. *E. jonesi.*
Fig. 154. *Cheladonta micheneri.*
Fig. 155. *C. ouachitensis* (sensillum).
Fig. 156. *Euschöngastia setosa.*

FIGURES 148-156

EXPLANATION OF FIGURES 157-168

Scuta of Nymphs. (to same scale except where indicated.)

Fig. 157. *Trombicula autumnalis* (not to same scale).
Fig. 158. *T. lipovskyi.*
Fig. 159. *T. whartoni.*
Fig. 160. *T. sylvilagi* (sensillum).
Fig. 161. *T. kardosi.*
Fig. 162. *T. ornata.*
Fig. 163. *T. crossleyi* (sensillum).
Fig. 164. *T. gurneyi.*
Fig. 165. *T. merrihewi.*
Fig. 166. *T. myotis.*
Fig. 167. *T. montanensis.*
Fig. 168. *T. alfreddugèsi.*

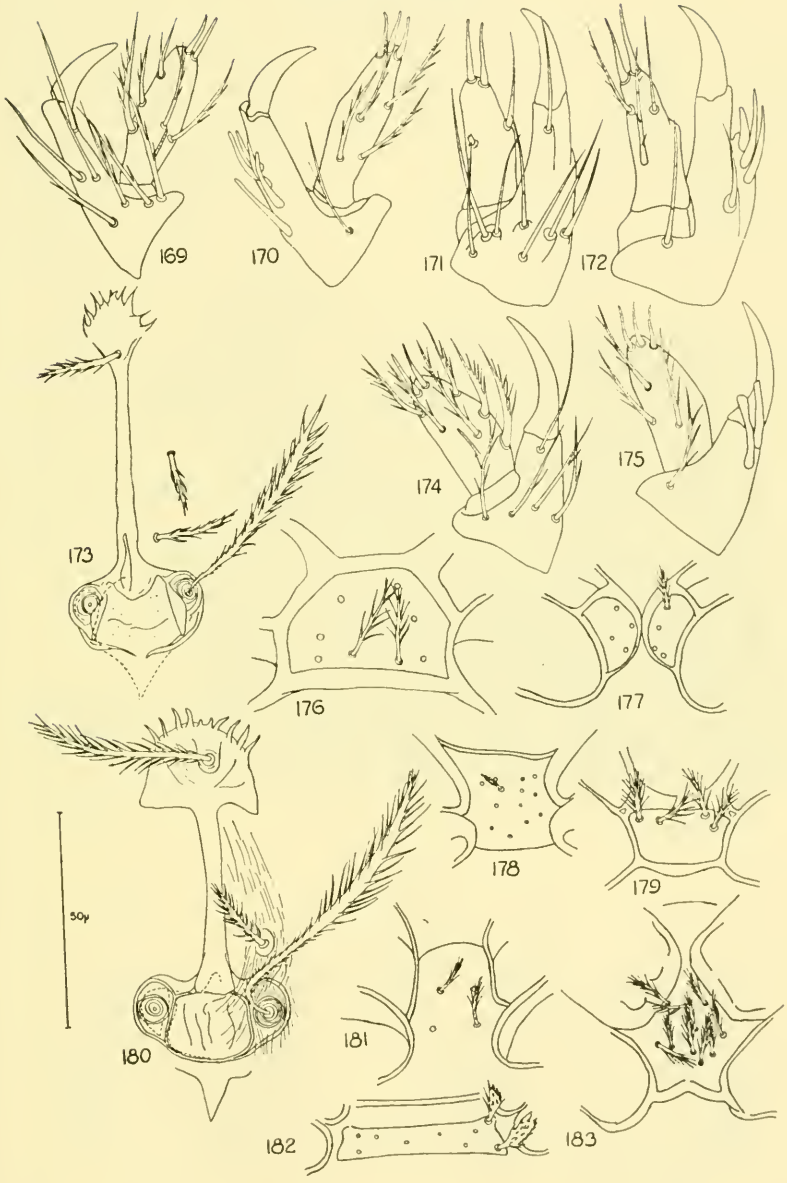
FIGURES 157-168

EXPLANATION OF FIGURES 169-183

Features of Nymphs. (Not to same scale.)

Fig. 169. *Blankaartia velascoi,* lateral view of palpal tibiotarsus.
Fig. 170. *B. velascoi,* medial view of palpal tibiotarsus.
Fig. 171. *B. alleei,* lateral view of palpal tibiotarsus.
Fig. 172. *B. alleei,* medial view of palpal tibiotarsus.
Fig. 173. *Speleocola tadaridae,* scutum.
Fig. 174. *Trombicula kardosi,* lateral view of palpal tibiotarsus.
Fig. 175. *T. kardosi,* medial view of palpal tibiotarsus.
Fig. 176. *T. splendens,* sternum.
Fig. 177. *Neoschöngastia americana,* sternum.
Fig. 178. *Hannemania multifemorala,* sternum.
Fig. 179. *Euschöngastoides hoplai,* sternum.
Fig. 180. *Neoschöngastia americana,* scutum.
Fig. 181. *Trombicula merrihewi,* sternum.
Fig. 182. *Whartonia senase,* sternum.
Fig. 183. *Cheladonta micheneri,* sternum.

FIGURES 169-183

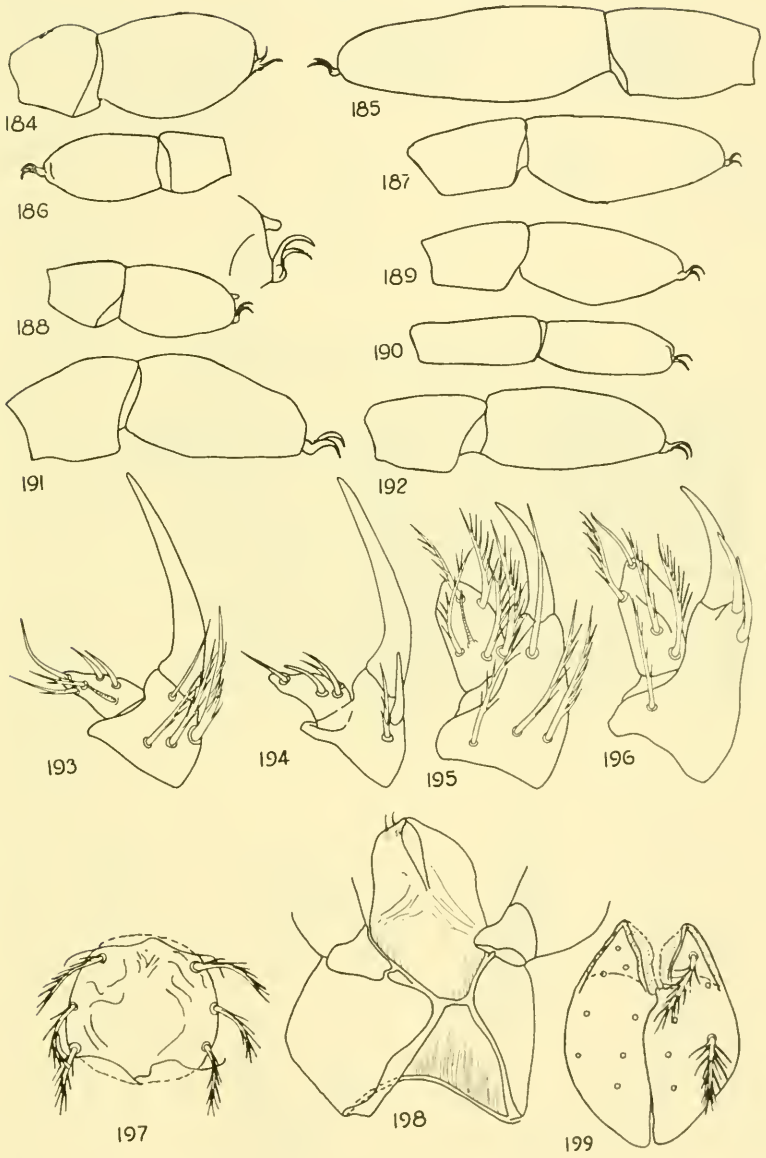


EXPLANATION OF FIGURES 184-199

Features of Nymphs. (Not to same scale.)

Fig. 184. *Cheladonta micheneri,* tibia and tarsus of leg I.
Fig. 185. *Leeuwenhoekia americana,* tibia and tarsus of leg I.
Fig. 186. *Euschöngastoides hoplai,* tibia and tarsus of leg I.
Fig. 187. *Whartonia senase,* tibia and tarsus of leg I.
Fig. 188. *Walchia americana,* tibia and tarsus of leg I.
Fig. 189. *Acomatacarus plumosus,* tibia and tarsus of leg I.
Fig. 190. *Chatia setosa,* tibia and tarsus of leg I.
Fig. 191. *Trombicula alfreddugèsi,* tibia and tarsus of leg I.
Fig. 192. *Euschöngastia trigenuala,* tibia and tarsus of leg I.
Fig. 193. *Neoschöngastia americana,* lateral view of palpal tibiotarsus.
Fig. 194. *N. americana,* medial view of palpal tibiotarsus.
Fig. 195. *Cheladonta micheneri,* lateral view of palpal tibiotarsus.
Fig. 196. *C. micheneri,* medial view of palpal tibiotarsus.
Fig. 197. *Leeuwenhoekia americana,* anus.
Fig. 198. *Trombicula tricetica,* dorsal view of basis capituli and hypostome (palpi still articulated at sides but chelicerae removed).
Fig. 199. *Trombicula splendens,* anus.

FIGURES 184-199

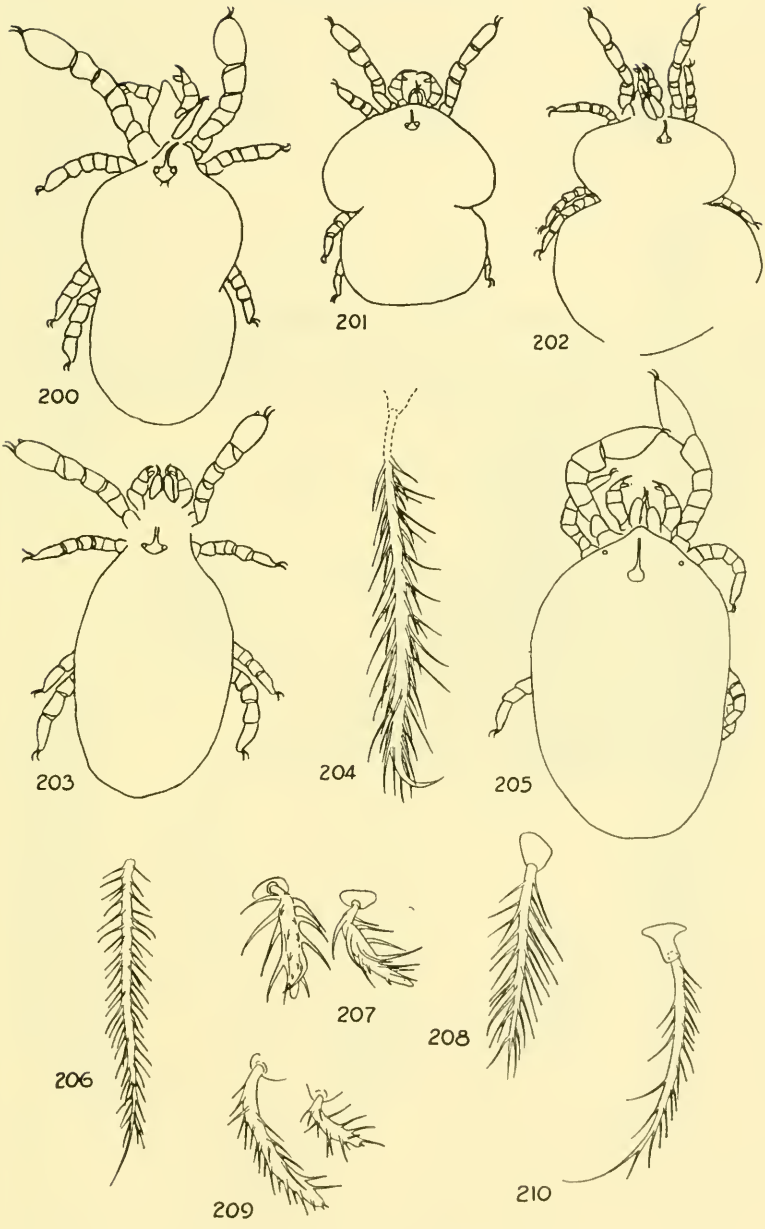


EXPLANATION OF FIGURES 200-210

Features of Nymphs. (Not to same scale.)

Fig. 200. *Cheladonta ouachitensis,* dorsal outline of body.
Fig. 201. *Neoschöngastia americana,* dorsal outline of body.
Fig. 202. *Trombicula ornata,* dorsal outline of body.
Fig. 203. *Walchia americana,* dorsal outline of body.
Fig. 204. *Hannemania dunni,* posterior body seta.
Fig. 205. *Acomatacarus plumosus,* dorsal outline of body.
Fig. 206. *Blankaartia velascoi,* posterior body seta.
Fig. 207. *Acomatacarus plumosus,* posterior body seta.
Fig. 208. *Blankaartia alleei,* posterior body seta.
Fig. 209. *Acomatacarus arizonensis,* posterior body seta.
Fig. 210. *Chatia setosa,* posterior body seta.

FIGURES 200-210

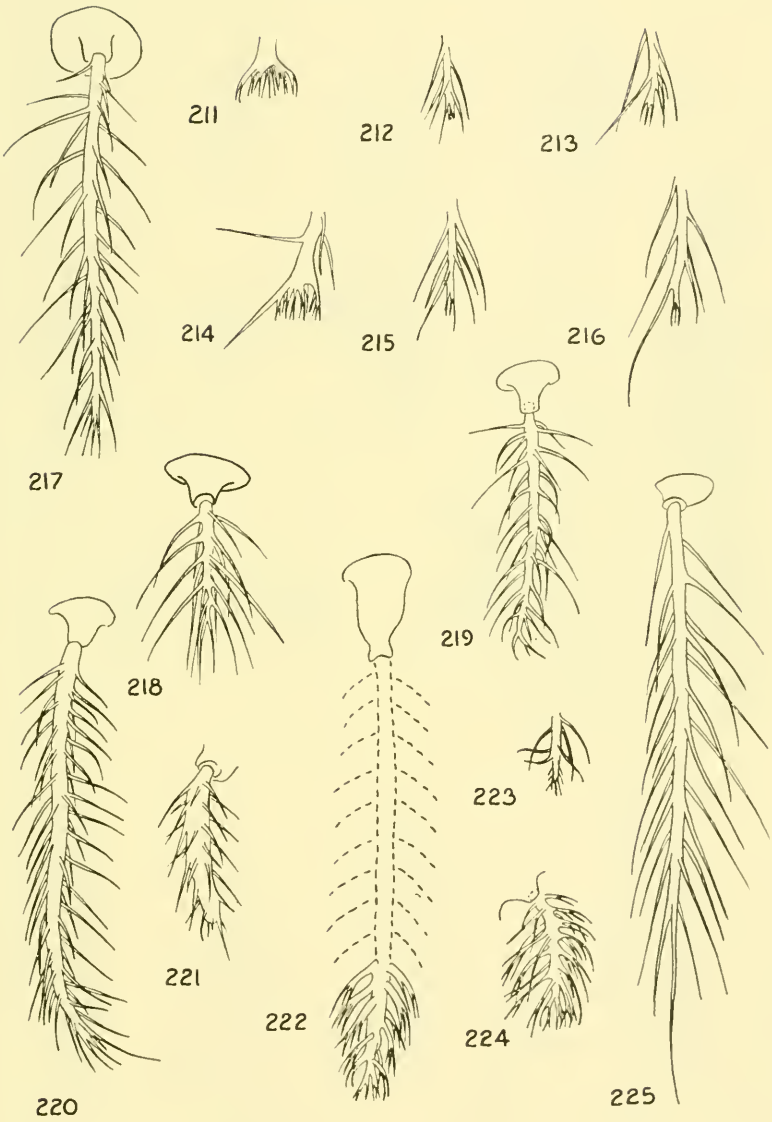


EXPLANATION OF FIGURES 211-225

Posterior Body Setae of Nymphs. (To same scale except where indicated.)

Fig. 211. *Euschöngastia peromysci* (tip) (Tennessee variant).
Fig. 212. *E. cynomyicola* (tip).
Fig. 213. *E. setosa* (tip).
Fig. 214. *E. peromysci* (tip) (Kansas variant).
Fig. 215. *E. diversa* (tip).
Fig. 216. *E. jonesi* (tip).
Fig. 217. *E. criceticola.*
Fig. 218. *Pseudoschöngastia hungerfordi.*
Fig. 219. *Euschöngastoides hoplai.*
Fig. 220. *Euschöngastia trigenuala.*
Fig. 221. *Cheladonta ouachitensis.*
Fig. 222. *Neoschöngastia americana* (long seta).
Fig. 223. *Euschöngastoides loomisi* (tip).
Fig. 224. *Neoschöngastia americana* (short seta).
Fig. 225. *Euschöngastia pipistrelli* (not to same scale).

FIGURES 211-225

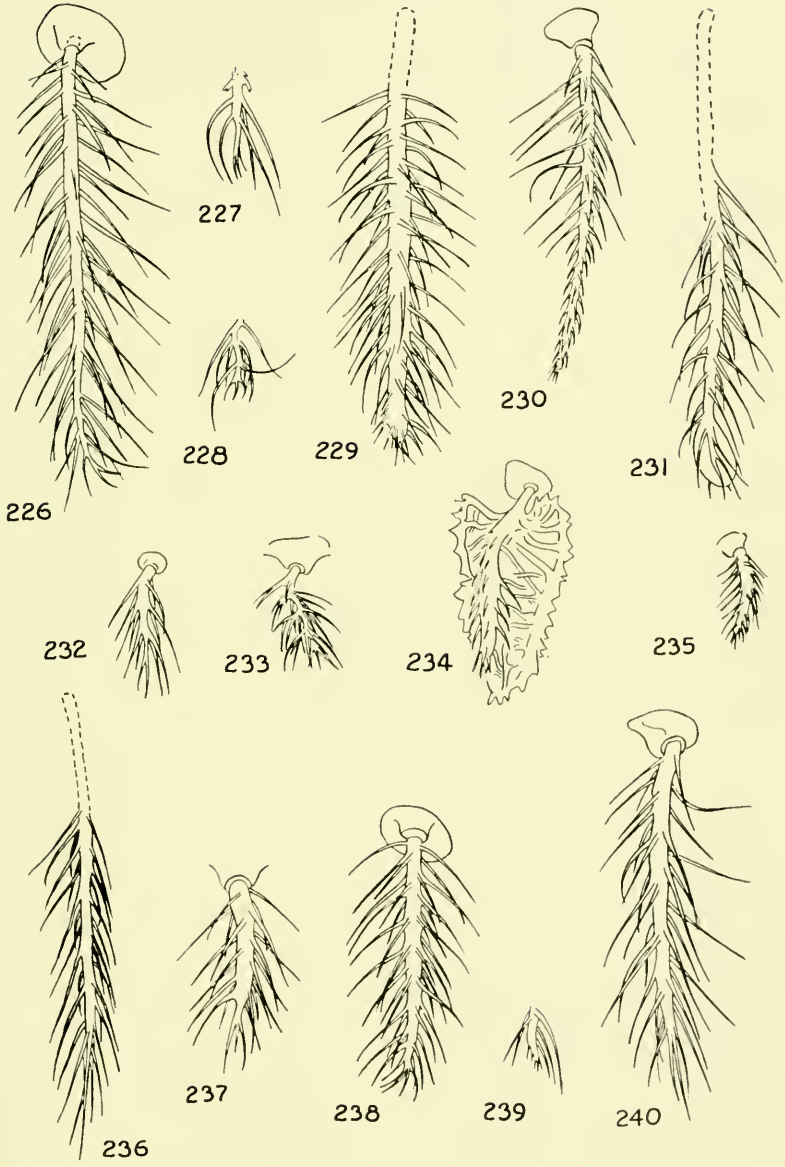


EXPLANATION OF FIGURES 226-240

Posterior Body Setae of Nymphs. (To same scale except where indicated.)

Figs. 226-227. *Trombicula alfreddugèsi.*
Fig. 228. *T. splendens* (tip).
Fig. 229. *T. belkini.*
Fig. 230. *T. fitchi* (not to scale).
Fig. 231. *T. myotis.*
Fig. 232. *T. merrihewi.*
Fig. 233. *Speleocola tadaridae.*
Fig. 234. *Whartonia senase.*
Fig. 235. *Walchia americana.*
Fig. 236. *Trombicula autumnalis.*
Fig. 237. *T. sylvilagi.*
Fig. 238. *T. gurneyi.*
Fig. 239. *T. montanensis.*
Fig. 240. *T. lipovskyi.*

FIGURES 226-240



THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XL] APRIL 20, 1960 [No. 7

Concerning the Genus *Ventidius* and Five New Species (Heteroptera, Gerridae)*

BY

HERBERT B. HUNGERFORD and RYUICHI MATSUDA

ABSTRACT—This paper contains the descriptions of five new species: *Ventidius malayensis* and *V. chinai* from Malay peninsula, *V. usingeri* and *V. werneri* from the Philippines, and *V.* (*Ventidioides*) *kuiterti* subg. et sp. nov. from Burma. It also presents a key to all the species of the genus.

The genus *Ventidius* was described by Distant for a small Halobatine gerrid from Travancore, India, which he named *Ventidius aquarius* (Ann. Mag. Nat. Hist., ser. 8, vol. 5, 1910, p. 150). In the Fauna of British India, Rhynchota V, Heteroptera, appendix p. 157 (1910) Distant figured both winged and wingless individuals of the same species. In 1918 Paiva described *V. distanti* from Yawnghwe State (now in East Burma) (Rec. Ind. Mus., vol. 14, p. 25, pl. 8, fig. 4). In 1930 Esaki described *V. henryi* from Ceylon (Jour. Fed. Malay Mus., vol. 16, p. 18, pl. 1 and 2). In 1933 Lundblad described *V. modulatus* from Java (Arch. Hydrobiol. Suppl. Bd. 12, Tropische Binnengewässer 4, s. 399). While all of these authors gave pictures of their species only Lundblad pictured the male genitalia of his species.

We thought it would be a simple matter to determine the specimens we have from Burma and Philippines. However, we found that the males of our Burmese species possessed two distinctive characters not mentioned in previous descriptions and this required the re-examination of the types and the assistance of the entomologists in charge of them. We are therefore grateful to Dr. W. E. China and Mr. R. J. Izzard of the British Museum for re-examining the types of *V. aquarius* and *V. henryi*, to Dr. A. P. Kapur of the Zoological Survey of India, Calcutta, for answering our inquiries about *T. distanti* Paiva, and to Dr. O. Lundblad of Stockholm, Sweden, for giving us additional information about his *V. modulatus*. With their help we have attempted to place the four described species, to describe five new species, and to propose a new subgenus to include two species that have characters not previously noted in the genus.

In course of our study we have found that the sutures occurring in the thorax and basal abdominal tergites are important in separating the species.

* Contribution No. 1011 from the Department of Entomology, University of Kansas. This paper is a by-product of a project by a grant from the National Science Foundation.

To facilitate the understanding of the description of these sutures in the text we have diagrammatically shown a hypothetically primitive *Ventidius* species possessing all sutures with which we are concerned on plate 3, figs. 1, 2.

Ventidius aquarius Distant

(Pl. 1, figs. 1, 2)

1910 Distant, W. L. Ann. Mag. Nat. Hist., ser. 8, vol. 5, p. 150 (described *Ventidius* with *aquarius* as the type species from Travancore, S. India).
1910 Distant, W. L. Fauna Brit. Ind. Rhynchota 5, Heteroptera: appendix pp. 157-158, fig. 84 (gives description and figures of winged and wingless individuals).
1911 Bergroth, E. Ann. Soc. Ent. Belgique, tome 60, p. 186 (considered *Ventidius* as a synonym of *Metrocoris* Mayr).
1928 Esaki, T. Ann. Mag. Nat. Hist., ser. 10, vol. 2, p. 572 (recorded from South India).
1928 Dover, C. Treubia, Deel 10, Afl. 1. Blz. 69 (says *V. distanti* Paiva is a synonym of *V. aquarius*).
1930 Esaki, T. Jour. Federated Malay Mus., vol. 16, p. 18, pls. 1 and 2 (says "a cotype of this species, a single apterous male* from Pallode near Trivandrum, Travancore, is now to be found in the British Museum. Its length of body is 3.5 mm., and ratio of its antennal segments:: 18:9:9:7. Then he gives a new record "1 ♀ Sungai Ampang, Selangor, Federated Malay State, Aug. 15, 1926 C. Dover." We found this to be another species.
1933 Lundblad, O. Arch. Hydrobiol. Suppl. Bd. 12, Tropische Binnengewässer, 4, S. 399.

Since we have not seen the type we quote Distant's description below and have copied the pictures given by him on pl. 1, figs. 1, 2.

"*Macropterous form:* Head and pronotum ochraceous, the latter with a large cruciform fascia and the sublateral and apical margins black; eyes black; hemelytra black; body beneath ochraceous; legs and apex of rostrum black, bases of anterior femora ochraceous; acetabula and coxae spotted with black; structural characters as in generic diagnosis.

"*Apterous form.* Body above ochraceous; pronotum with a narrow sublateral fascia, angulated and reaching margin at humeral angle, and two spots at centre of posterior margin continued across mesonotum, black, other markings generally as in macropterous form; abdomen above ochraceous, with the segmental margin black.

"Length, macropt. form 5 mm., apt. form 4½ mm.

"*Hab.* Travancore, Pallode, 20 miles N. E. of Trivandrum (Annandale) 'On roadside jungle stream (N. Annandale)'." An apterous female specimen from Travancore is in the British Museum.

This species is known only from the types from Travancore, South India. Dover considered *V. distanti* to be a synonym of *V. aquarius*,

* In 1958 Dr. China wrote us that the single cotype of *V. aquarius* in the British Museum is a female, apterous, and lacks entirely the intersegmental suture between the meso- and metanota.

but we believe he was in error. Dr. A. P. Kapur wrote to us that they have a single female apterous specimen of this species from Travancore. A more satisfactory description of this species awaits the capture of more specimens from South India. The specimens reported by Esaki from the Malay Peninsula (1930) are of a new species described below.

Ventidius malayensis sp. nov.

(Pl. 1 fig. 8, Pl. 3 figs. 3, 5, 12)

Size: Apterous male 3.99 mm. long; 2.94 mm. wide across mesoacetabula. Apterous females 3.57-4.1 mm. long; 2.94-3.05 mm. wide across mesoacetabula.

Color: Shining testaceous, with dark brown to black markings as shown in the figures on plate 2. Antennae except base of first segment and legs, except basal half of front femur, black. Venter pale.

Structural characteristics: Relative lengths of antennal segments in male: 1st:2nd:3rd:4th::90:60:32:40; in female: 72:35:27:27. Male with a tuft of hairs near distal end of third segment. Anterior margin of head somewhat produced beyond eyes which are sloping and overlap lateral margins of prothorax and anterolateral angles of mesothorax. Prothorax short, about half as long as head, with anterior and posterior margins medially concave. Mesonotum swollen. Intersegmental suture between meso- and metanota faint to obscure. Metanotum somewhat declivent; lateral suture of metanotum not reaching the intersegmental suture anteriorly; lower half of hind margin of metacetabula nearly transverse and broad; omphalium present. Anterior margin of first tergite lost. Connexivum broad. Last abdominal ventrite as long as preceding segments taken together in both sexes. Front tibia somewhat swollen in the middle, claws arisê from near base of second segment instead of near its middle as in *V. aquarius* and *V. usingeri.*

Relative lengths of leg segments of a male.

	Femur	Tibia	First tarsal	Second tarsal	Total of tarsal segments
Front leg	225	205	17	80	97
Middle leg	640	390	?	?	?
Hind leg	690	360	80	30	110

Paramere small and symmetrical as in *V. usingeri* n. sp. but a little different in shape. (See pl. 3 fig. 12).

Location of types: The male holotype and the female allotype bear the label "Malay Peninsula, Selangor, F. M. S. Sungai Ampang, Aug. 15, 1926 C. Dover, Ex. Coll. F. M. S. Museum." The male holotype is also labelled "*Ventidius aquarius* Dist. det. by Teiso Esaki," and the female allotype bears also the label "*Metrocoris aquarius* Dist. det. Dover 26." A female paratype is labelled "Malay Penin. Upper Perak, Lenggong Surface of irrigation channels fast water I. H. N. E. 22 X 5—XI 1926 C. Dover" and on the reverse side "Ex. coll. F. M. S. Museum ♀." All the types are preserved at the British Museum.

Ventidius usingeri sp. nov.

(Pl. 2 figs. 7, 8, Pl. 3 figs. 4, 10)

Size: Winged male 4.2 mm. long; 2.06 mm. across humeri; 2.48 mm. across mesoacetabula. Winged female 4.62 mm. long; 2.1 mm. across humeri; 2.56 mm. across mesoacetabula. Wingless female 3.68 mm. long; 2.73 mm. across mesoacetabula.

Color: Winged form pale yellowish with dark hemelytra, pronotal black marking as shown on pl. 2. Apterous female with black markings as shown on pl. 2, and the pale caudal lobe on metanotum broadly rounded behind instead of having an angular projection as in *V. aquarius*. The black markings, under certain reflections, appear as iridescent green.

Structural characteristics: Relative lengths of antennal segments in male: 1st: 2nd: 3rd: 4th::75:53:38:28; in female::75:43:35:26. In winged forms eyes overlapping lateral region of prothorax, not quite reaching propleural caudal margin. Caudal tip of pronotum surpassing a line drawn between metathoracic spiracles; pale median longitudinal line of pronotum bordered with dark lines gives an appearance of being a carina. In wingless forms eyes overlap lateral margins of prothorax and anterolateral angles of mesothorax. Anterior and posterior margins of pronotum medially concave. Intersegmental suture between meso- and metanota distinct in one apterous female. Lateral suture of metanotum not reaching intersegmental suture between meso- and metanota. Anterior margin of first abdominal tergite obscure. Lower half of hind margin of metaacetabula nearly transverse and broad. Last abdominal ventrite in both sexes as long as all preceding segments together. Parameres small and nearly symmetrical, only half as long as those in *V. distanti* which is a much smaller species. Front

femur of male not swollen, very slightly curved and without a tubercle on ventral side. First tarsal segment of middle leg curved and ventrally hairy at base in both sexes. The male lacks mesosternal tubercle.

Relative lengths of leg segments of a male.

	Femur	Tibia	First tarsal	Second tarsal	Total of tarsal segments
Front leg	210	178	10	53	63
Middle leg	530	330	167	26	193
Hind leg	575	240	48	37	85

Location of types: The holotype is a winged male bearing the labels "Los Baños P. I. VII-17-1936," and "R. L. Usinger collector," and belongs to the Usinger collection. The allotype is a winged female bearing the labels "C N H M Philippines Zool. Exped. (1946-1947)" and "Borungkot, Upi, Cotabato Province, Mindanao 1500 ft. '47." This belongs to the Chicago Natural History Museum. A wingless paratype female specimen came from the same place as the allotype and is in the Francis Huntington Snow museum, University of Kansas.

Comparative notes: This species appears very much like *V. aquarius,* which was described from Travancore, South India. The shape and size of parameres are as in *V. malayensis* sp. nov., but the relative lengths of antennal segments are different and the male of *V. malayensis* has a tuft of hairs near the distal end of the third antennal segment, which is lacking in this species. As in *V. aquarius* the front leg has the claws arising from near the middle of the second tarsal segment.

Ventidius henryi Esaki

(Pl. 1 figs. 3, 4, Pl. 2 fig. 6, Pl. 3 fig. 8)

1928 *Ventidius henryi* Esaki, T. Ann. Mag. Nat. Hist. ser. 10, vol. 2, pp. 509-511 (described from Kitulgala, Ceylon. 1 ♂, 3 ♀ ♀).

1933 *Ventidius henryi* Lundblad, O. Arch. Hydrobiol. Suppl. 12, Tropische Binnengewässer 4, S. 372 (records Ceylon).

Dr. W. E. China of the British Museum kindly answered our inquiry by reporting that they have one male (type) and one female from Ceylon, and that the mesosternum in the male specimen is spoiled by the pin, and also that the anterior femora lack the small tubercle present in *V. kuiterti* sp. nov.

We are grateful also to Dr. P. E. P. Deraniyagala, Director of the National Museum, Colombo, Ceylon, for sending us in alcohol 15 adults and 11 nymphs taken from Kitulgayala in Sabaragamuwa Prov., Ceylon, in December 1934. These are therefore possibly from the type locality but not of the type series and enable us to add to the kownledge of this species, for Esaki knew only apterous specimens and did not describe the male parameres.

Size: Winged female: 2.73 mm. long; across humeri 1.5 mm. wide; across mesoacetabula 1.8 mm. wide. Wingless female: 2.5-2.94 mm. long; across mesoacetabula 1.78-1.89 mm. wide. Wingless males: 2.3-2.4 mm. long; across mesoacetabula 1.43-1.5 mm. wide. Although Esaki gives the male as 2.4 mm. long and 1.8 mm. wide, and the female as 2.2 mm. long and 1.6 mm. wide in our specimens the females are all larger than the males.

Color: Wingless forms have the pattern as shown on pl. 1 fig. 4. Surface not shining, finely pilose. Pale band on head usually reddish, the other spots stramineous. Pronotum black. Sides of mesothorax with longitudinal dark brown to black band behind eyes. Venter pale. Antennae except base, legs and beak brown. Winged specimen which is teneral dark brown instead of black in ground color on upper surface; head wtih the characteristic reddish band and pronotum with stramineous spots.

Structural characteristics: Relative length of antennal segments in male: 1st: 2nd: 3rd: 4th::46:20:18:16; in female: 45:18:20:18 (with some variations). While Esaki gives the formula for the species as 50:20:20 he says "second, third and fourth segments nearly equal in length." Eyes in apterous forms overlapping lateral margins of prothorax and anterolateral angles of mesothorax. Anterior margin of pronotum between eyes nealy straight, posterior margin concave. Intersegmental suture between meso- and metanota faint to obscure. Lateral suture of metanotum not reaching intersegmental suture anteriorly. Anterior margin of first tergite faint to obscure. Lower half of caudal margin of metaacetabula oblique, its lower angle nearly pointed. Omphalium visible. Last abdominal ventrite short, scarcely as long as total length of all abdominal ventrites that precede it and much shorter than the venter of eighth segment in male. Eighth ventrite a little longer than all segments together that precede it in male. Last ventrite in female short, not as long as all preceding segments together. Front femur without protuberance in male and mesosternum lacks a protuberance in male. Parameres as shown on pl. 3 fig. 8. They are symmetrical.

Relative lengths of leg segments of a male.

	Femur	Tibia	First tarsal	Second tarsal	Total length of tarsus
Front leg	135	120	10.2	37.8	48
Middle leg	405	219	116.7	24.3	141
Hind leg	450	145	28.0	29.0	57

Location of types: The types are in the British Museum. The specimens studied in this work are in the Francis Huntington Snow Museum, University of Kansas.

Ventidius modulatus Lundblad

(Pl. 1, fig. 7)

1933 *Ventidius modulatus* Lundblad, O. Arch. Hydrobiol. Suppl. Bd. 12. Tropische Binnengewässer 4, S. 399-401, Taf. 12, and fig. 128.

Dr. Lundblad gave an excellent description and good illustration of this species from West Java. We give here some statements from his description.

Size: About 2.5 mm. long.

Color: Ground color lemon yellow. Head with a small brown fleck in front. Behind each eye on pro-, meso-, and metanotum with a fairly broad brown longitudinal band. Behind the boundary of meso- and metanota with a lateral band of brown color, which may be free at its end or be joined to a dark fleck on metaacetabula. Base of antennae and of front leg yellowish. Anterior abdominal tergites dark as shown on plate, or have yellowish triangular flecks in the middle. Posterior tergites and the entire venter always yellow. Connexivum largely yellow.

Structural characteristics: Relative lengths of antennal segments: 1st: 2nd: 3rd: 4th::53:27.6:20.3:19. The suture between meso- and metanota distinct, also the one between metanotum and first abdominal tergite distinct. First three abdominal tergites confluent without distinct sutures (with distinct sutures in Taf. 12). Male paramere relatively large.

Location of types: Described from four males taken from West Java, Stausee Tjigombong, south of Buitenzorg, 500 m. above sea level. 17. IX. 1928. Types are in the National Museum, Stockholm, Sweden.

Ventidius werneri sp. nov.

(Pl. 2 figs. 4, 5, Pl. 3, fig. 11)

Size: Wingless male 2.2 mm. long; 1.55 mm. wide. Wingless female 2.3 mm. long; 1.68 mm. wide.

Color: Black with whitish or yellowish white figures as shown on plate 2. Head mostly whitish, with a black spot on vertex and a black band along inner margin of each eye. Antennae black except base of first segment. Pronotum black laterally, with a transverse triangular whitish spot, its apex almost reaching anterior margin of pronotum. The remaining thoracic dorsum with a large conspicuous whitish spot that is broad at its apex and broadly bilobed caudally; the large whitish spot on metanotum broadly continuous with mesonotal whitish spot. Mesothoracic pleuron behind eye somewhat embrowned but lacking usual brown or black band. Metaacetabular elongate whitish spot with its lower margin with a dentate projection before middle and a lobate projection at caudal angle. Abdominal tergites black, with last five or six tergites of female with median pale spots or bands that may cover most of the tergites; those of male mostly black. Connexival segments of female whitish; last five segments of male whitish. Legs black except base of front femora.

Structural characteristics: Relative lengths of antennal segments in male: 1st: 2nd: 3rd: 4th:: 48:22:19:20, those of female ::43:19:21:19. Eyes in wingless forms overlapping lateral margins of prothorax and anterolateral angle of mesothorax. Anterior and posterior margins of pronotum concave. Mesonotum swollen. Metanotum more or less declivent. Intersegmental suture between meso- and metanota faint to obscure. Lateral suture of metanotum not quite reaching intersegmental suture between meso- and metanota. Caudal margin of metaacetabula oblique and lower angle nearly pointed. Front femora slightly curved in basal half; that of male not thicker than that of female and without the tubercle charac-

Relative lengths of leg segments of a male.

	Femur	Tibia	First tarsal	Second tarsal	Total of tarsal segments
Front leg	140	114	7	38	45
Middle leg	375	190	115	20	135
Hind leg	360	150	23	30	53

teristic of *V. kuiterti.* Male also lacks tubercle on mesosternum. First tarsal segment of middle leg curved, thickened and ventrally hairy at base in both sexes.

Location of types: Described from one male and two females labelled "CNHM Philippines Zool. Exped. (1946-47). F. G. Werner, Puerto Princesa, Palawan Is. Sea level, March (1947)." Holotype and allotype are in the Chicago Natural History Museum, and a female paratype is in the Francis Huntington Snow Museum, University of Kansas.

Comparative notes: This species, which is about the same size as *V. distanti,* has larger pale spots on pronotum and the mesonotal spot is much broader anteriorly. The male lacks the tubercle of front femur and the mesosternal tubercle.

Ventidius chinai sp. nov.

(Pl. 1 figs. 5, 6, Pl. 3 fig. 9)

Size: Wingless males 2.56-2.73 mm. long; across mesoacetabula 1.89 mm. wide. Wingless female 2.94 mm. long; 2.18-2.27 mm. wide across mesoacetabula.

Color: Body pale stramineous. Antennae and legs, except base of first antennal segment and of front femur, black. If any dark spots occur on the body they are on sides of notum and base of abdomen.

Structural characteristics: Relative lengths of antennal segments in male: 1st: 2nd: 3rd: 4th ::56:28:20:20; those in a female ::48:22:26:?. Eyes in wingless forms overlapping lateral margins of prothorax and anterolateral angles of mesothorax. Anterior and posterior margins of pronotum medially concave. Mesonotum somewhat swollen. Intersegmental suture between meso- and metanota obscure. Metanotum slightly declivent; lateral suture of metanotum not reaching intersegmental suture between meso- and metanota. Anterior margin of first tergite distinct; basal abdominal tergites produced anteriorly, anterior margins obliterated medially on sec-

Relative lengths of leg segments of a male.

	Femur	Tibia	First tarsal	Second tarsal	Total of tarsus
Front leg	150	135	7.8	37.2	45
Middle leg	450	246	129.6	20.4	150
Hind leg	450	200	25.0	30.0	55

ond and third; last abdominal ventrite as long as all the preceding segments together in both sexes. Connexivum rather broad. Hind margin of metaacetabula oblique and lower angle nearly pointed. Front femur of male without protuberance and not thicker than that of female. Mesosternum in male lacks protuberance.

Male parameres are symmetrical and of characteristic shape; distal end broadened and appears lobed in certain views. (Pl. 3, fig. 9.)

Location of types: Described from two wingless males and two wingless females bearing the label "Malay Peninsula, Selangor, F. M. S. Kajang Sungei Lang Feb. 12, 1927," on the reverse side "C. Dover, Coll. F. M. S. Museum." They also bear another label "*Ventidius* sp. nov. det. W. E. China 1934." The holotype male, allotype female and two paratypes are in the British Museum.

Comparative notes: The surface of this pale species is shining and nearly devoid of hairs. It is smaller than *V. aquarius*.

Ventidius distanti Paiva

(Pl. 2, fig. 1)

1918 *Ventidius dis'anti* Paiva, C. A. Rec. Ind. Mus., vol. 14, p. 25, Plate 8, fig. 4.
1928 *Ventidius distanti* Esaki, T. Ann. Mag. Nat. Hist. ser. 10, vol. 2, p. 511.
1929 *Ventidius distanti* Dover, C. Treubia, Deel 10, Afl. 1, Blz. 69 (part. ?).
1930 *Ventidius distanti* Esaki, T. Jour. Fed. Malay Mus., vol. 16, p. 18 (considers it to be a good species).
1933 *Ventidius distanti* Lundblad, O. Arch. Hydrobiol. 1933 Suppl. Bd. 12, Tropische Binnengewässer 4, S. 372.

In a paper entitled "Aquatic Rhynchota from the Southern Shan States" Paiva described this species "from several specimens in alcohol from the top of the gorge of the He-Ho River, Yawnghwe State ca. 3.500 ft., 7-iii-1917." We quote his description and reproduce his illustration on plate 2.

"*Apterous form.* Head black with a large patch at base and a transverse fascia at apex of face yellowish ochraceous; eyes silvery grey, with a black patch on the disk; antennae black, basal half of first joint yellowish.

"Pronotum very short, black, a narrow ochraceous waved fascia at basal margin, anterior margin slightly concave, posterior margin almost straight. Mesonotum large, about as long as its greatest breadth, covered with decumbent hairs, disk obliquely striate on anterior area, ochraceous, with two broad lateral black fasciae curved inwards anteriorly and meeting narrowly on anterior margin, each extended posteriorly to meet a curved fascia on the intermediate acetabula; a large subtriangular patch at centre of posterior margin; the posterior lateral angles narrowly dull black.

"Metanotum dull black with a small ochraceous spot near each basal angle.

"Abdomen above dull white, the basal segment, a spot at lateral margin of each segment and the apical segment black.

"Underside pale ochraceous; legs black, base of anterior femora ochraceous.

"Length 3 mm."

Type No. 7125/ H. I. in the collection of the Zoological Survey of India.

Dr. A. P. Kapur of the Calcutta Museum is now unable to find this type in their museum and it may have been lost by high water in the temporary quarters in 1943. This is most unfortunate since only a re-examination of the type or a study of a series of specimens from the type locality the identity of *Ventidius distanti* can be established.

Dover (1928) states that "Paiva's *V. distanti* is based on apterous males which are very different in coloration from the females. I have taken specimens in Kuala Lumpur which agree exactly with Paiva's description and figure in copulation with specimens as described by Distant." We know that Dover had two species before him from Selangor, F. M. S. and had labelled the larger species as "*Metrocoris aquarius* Distant" in error. This we have described as a new species. The smaller species which he had from Selangor, F. M. S. is at least subgenerically distinct from *Ventidius* and the males are less than 3 mm. long and the pronotum is entirely black (Paiva gives for *V. distanti* 3 mm. long and a narrow ochraceous waved fascia at basal margin of the very short black pronotum). Whether this can be *V. distanti* or not we cannot determine. Both Esaki and China have determined these specimens as *V. distanti.* Since, besides their smaller size and different color pattern, the males have a tubercle on the ventral side of the front femur and a black tubercle on the mesosternum that are not mentioned in Paiva's description of *V. distanti* we must question their determination. It may belong to the new subgenus *Ventidioides* along with *V. kuiterti* sp. nov. or be something quite different.

Ventidius (*Ventidioides*) *kuiterti* sp. nov.

(Text fig. 1, Pl. 2, figs. 2, 3, Pl. 3, figs. 6, 7)

Size: Wingless male: 2.3 mm. to 2.5 mm. long; across metaacetabula 1.57 mm. to 1.59 mm. wide. Wingless female: 2.7 mm. to 2.95 mm. long; across metaacetabula 2.1 mm. wide.

Color: Black with whitish or yellowish-white figures as shown on plate. These figures somewhat variable in shape and size.

Metanotal pale spots sometimes joining the posterior lobes of mesonotal pale spot. Abdominal spots sometimes joining posterior lobes of mesonotal pale spot. Abdominal spots vary from three to seven in number. Connexival segments of female whitish, of males black except last two. Metacetabular elongate whitish spot with bidentate lower margin. Venter and coxae whitish. Antennae black except base of first segment and third segment sometimes pale. Legs black except base of front femora.

Structural characteristics: Antennae as long as body in male, somewhat shorter than body in female. Relative lengths of antennal segments in male: 1st: 2nd: 3rd: 4th::60:18:20:24; and those in female ::47:15:23:22. Eyes in wingless forms overlapping lateral margins of prothorax and anterolateral angles of mesothorax. Anterior and posterior margins of pronotum medially concave. Mesonotum swollen. Metanotum more or less declivous. Intersegmental suture between meso- and metanota as well as anterior margin of first tergite obliterated or lost. Abdomen reduced.

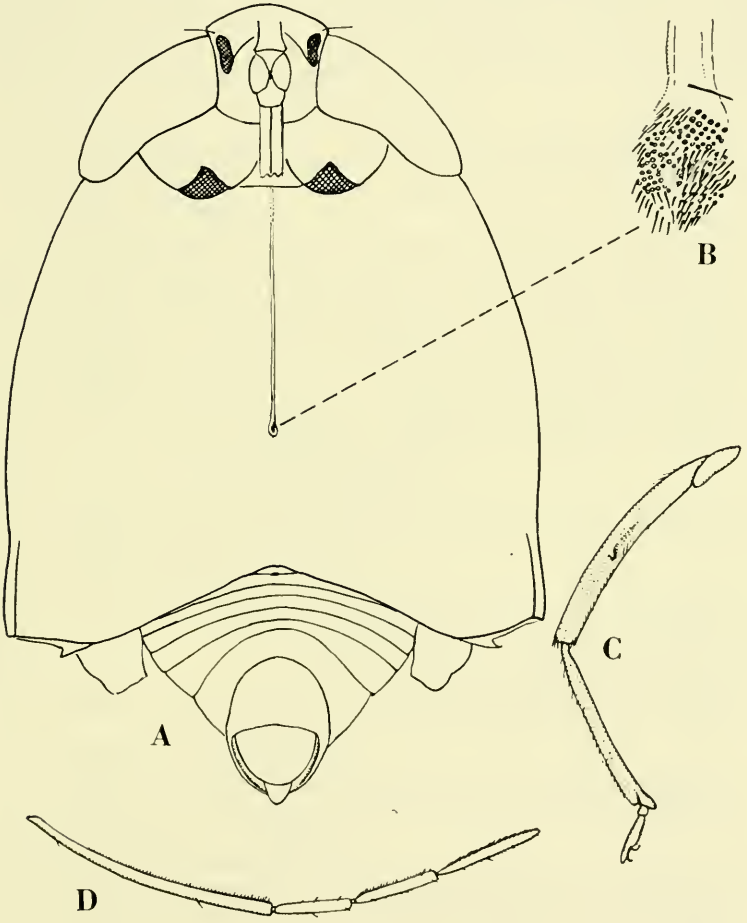
Relative lengths of leg segments of a male.

	Femur	Tibia	First tarsal	Second tarsal	Total of tarsus
Front leg	140	115	8	34	42
Middle leg	388	205	110	26	136
Hind leg	430	140	24	30	54

Connexivum relatively broad. Basal abdominal tergites more or less fused, only the last five distinct. Last ventral abdominal segment as long as five preceding segments together in both sexes. Front femur slightly curved in basal third and that of male somewhat thickened and with a tubercle on the middle of ventral side. Right paramere of male smaller and somewhat different in shape from the left paramere (see pl. 3 figs. 6, 7). The male also possesses a median dark tipped tubercle* on the mesosternum that appears to be the caudal end of a tube. This is far in front of the omphalium which lies on the small triangular metasternal piece. Females lack this tubercle and males of other species of *Ventidius* must lack it since it has not been described (see pl. 3 figs. 6, 7).

* We cleared a male in caustic potash and mounted the thoracic venter on a slide. Under 16 mm. objective of the compound microscope (100x) the dark spot on the tip of the tubercle is at the caudal end of a long median longitudinal duct. Under 4 mm. objective (440x) the dark spot is a cluster of minute setae but no definite pore-opening for the duct is visible. The setae resemble glandular setae arising from circular trichophores.

Location of types: Described from fifteen males and thirty-five females bearing the label "Shingbwiyang, Burma III 24-1944 Lt. L. C. Kuitert," and five males and six females from the same area on VIII, 17-1944 by L. C. Kuitert. The male holotypes, female



Text fig. 1. *Ventidius (Ventidioides) kuiterti* sp. nov.

A. Ventral view.
B. The tubercle enlarged (× 440).
C. The male front leg.
D. The male antenna.

allotype and paratypes are in the Francis Huntington Snow Museum, University of Kansas.

Comparative notes: This species is the first one described in the genus *Ventidius* that shows sexual dimorphism in the front leg and the mesosternum. The males have a ventral projection on the front femur and a mesosternal tubercle.

SEPARATION OF VENTIDIUS DISTANT FROM ESAKIA LUNDBLAD AND KEY TO THE SPECIES OF VENTIDIUS

1. In wingless forms lateral longitudinal suture of metanotum reaching intersegmental suture between meso- and metanota. Third and fourth segments of male antennae somewhat enlarged and fringed with hairs ..... *Esakia* Lundblad
1'. In wingless forms lateral longitudinal suture of metanotum not reaching intersegmental suture between meso and metanota. Third and fourth segment of male antennae normal... *Ventidius* Distant (2)
2. Posterolateral angle of metaacetabula transverse and broad or oblique. Males without a tubercle on front femur, and without a small tubercle on mesosternum..... ....*Ventidius (Ventidius)* (3)
2'. Posterolateral angle of metaacetabula bilobate. Males with a tubercle on front femur and with a small black tubercle on mesosternum. Parameres of male asymmetrical and large. *Ventidius* (*Ventidioides*) subgen. nov. (9)
3. Front tarsal claws arising from near base of second tarsal segment and male with a tuft of hairs on third antennal segment. *V. (Ventidius) malayensis* sp. nov.
3'. Front tarsal claws arising from nearer the middle than base of second segment. Male antennae without tuft of hairs ..... (4)
4. Size rather large (3.5 mm. long or longer)..... (5)
4'. Size smaller (less than 3 mm. long)..... (6)
5. Antennal segments three and four about equal in length. Winged form with a T-shaped black figure on pronotum. *V. (Ventidius) aquarius* Distant
5'. Antennal segment three considerably longer than four (38:28). Winged form with a median longitudinal pale line on pronotum. *V. (Ventidius) usingeri* sp. nov.
6. In wingless forms intersegmental suture between meso- and metanota distinct; intersegmental suture between metanotum and first tergite especially distinct. Parameres of male club shaped with a protuberance on rear margin .*V. (Ventidius) modulatus* Lundblad
7. Upper surface of body with considerably large brown or black areas, head with brown or black spots..... (8)
7'. Upper surface of body largely stramineous, head entirely stramineous .....*V. (Ventidius) chinai* sp. nov.
8. Pronotum black with a pale transverse triangular area. *V. (Ventidius) werneri* sp. nov.

8'. Pronotum solid black or brown except on winged form which has two pale spots ..... *V. (Ventidius) henryi* Esaki

9. Stramineous metanotal lobes very broadly continuous to mesonotal spot. Base of pronotum transversely white.
V. (Ventidioides) distanti Paiva (?)*

9'. Stramineous metanotal lobes not or narrowly continuous to mesonotal spot. Pronotum entirely black.
V. (Ventidioides) kuiterti sp. nov.

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* Based on determinations by Drs. China and Esaki.

PLATE I

1. *V. (Ventidius) aquarius* Distant. Winged form (copied from Distant, 1910).
2. *V. (Ventidius) aquarius* Distant. Wingless female (?) (copied from Distant).
3. *V. (Ventidius) henryi* Esaki. Winged female.
4. *V. (Ventidius) henryi* Esaki. Wingless male.
5. *V. (Ventidius) chinai* sp. nov. Wingless male.
6. *V. (Ventidius) chinai* sp. nov. Wingless female.
7. *V. (Ventidius) modulatus* Lundblad. Wingless male (copied from Lundblad, 1933).
8. *V. (Ventidius) malayensis* sp. nov. Wingless female.

PLATE I

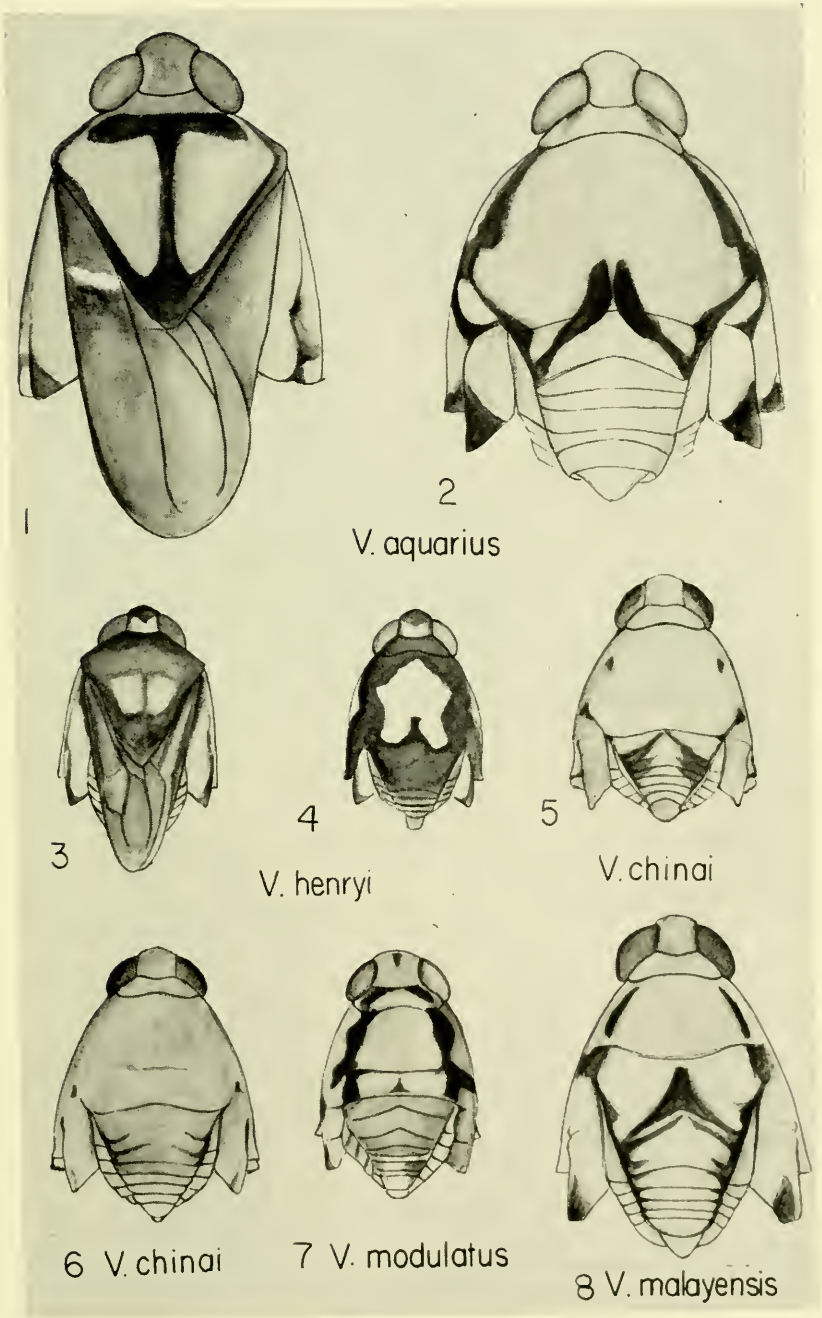

1
2
V. aquarius
3
4
V. henryi
5
V. chinai
6 V. chinai
7 V. modulatus
8 V. malayensis

PLATE II

1. *V. (Ventidius) distanti* Paiva. Wingless female (copied from Paiva, 1918).
2. *V. (Ventidius) kuiterti* sp. nov. Wingless male.
3. *V. (Ventidioides) kuiterti* sp. nov. Wingless female.
4. *V. (Ventidius) werneri* sp. nov. Wingless male.
5. *V. (Ventidius) werneri* sp. nov. Wingless female.
6. *V. (Ventidius) henryi* Esaki. Wingless female.
7. *V. (Ventidius) usingeri* sp. nov. Winged female.
8. *V. (Ventidius) usingeri* sp. nov. Wingless female.

PLATE II

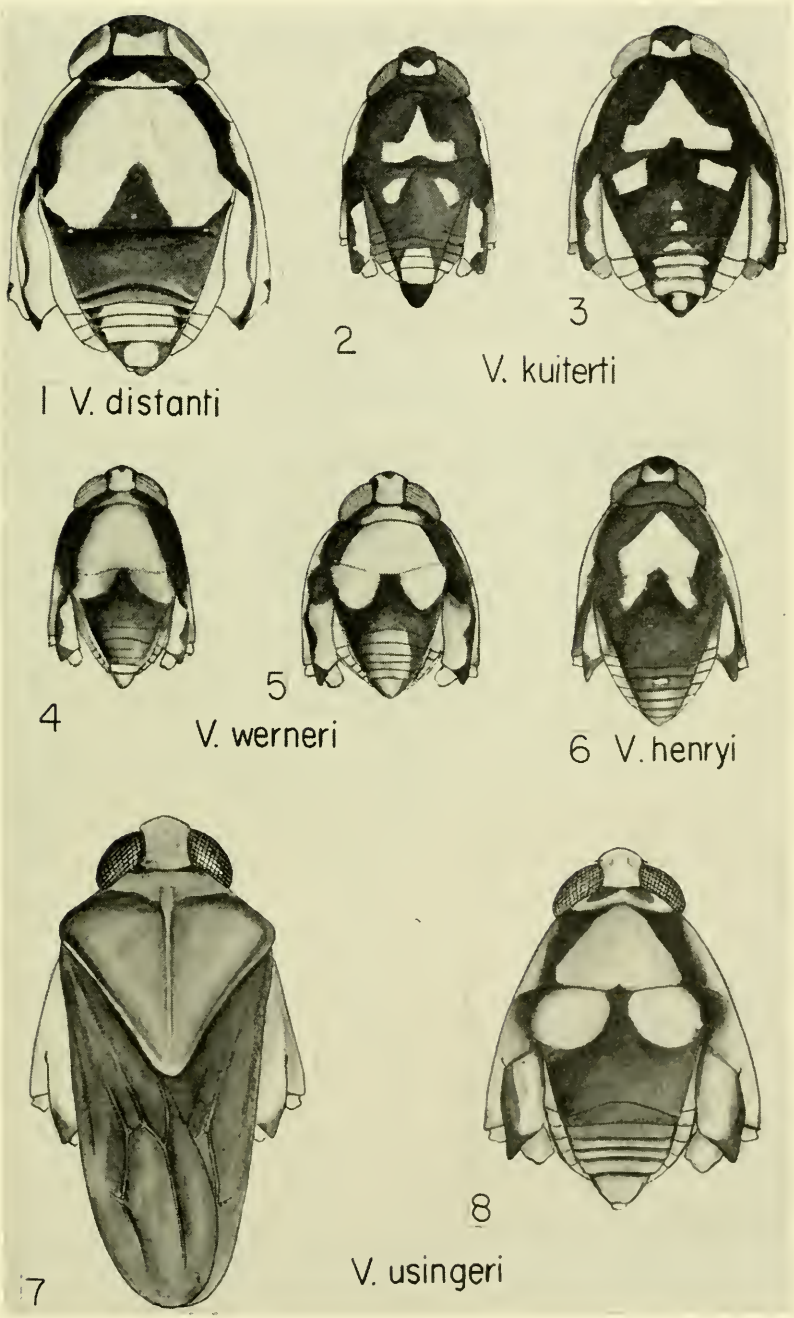
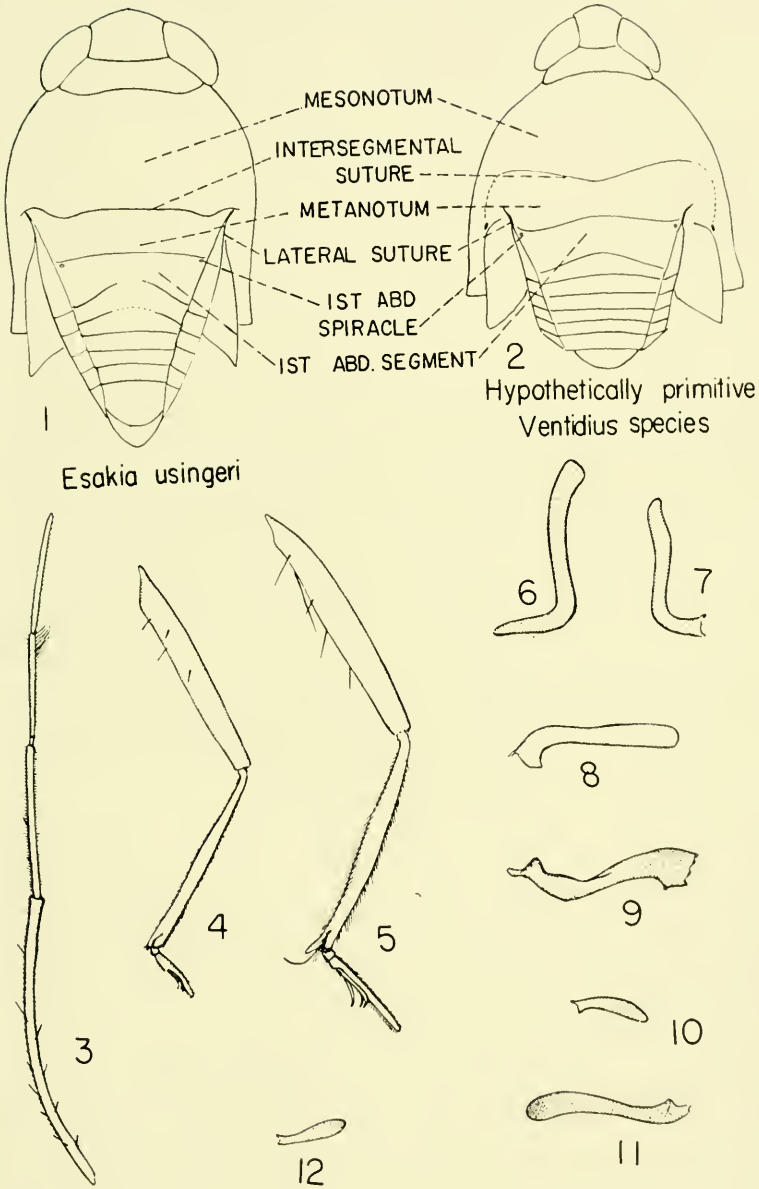

1 V. distanti
2
3
V. kuiterti
4
5
V. werneri
6 V. henryi
7
8
V. usingeri

PLATE III

1. *Esakia usingeri* sp. nov.
2. A hypothetically primitive species of *Ventidius* with all thoracic and abdominal sutures retained.
3. The male antenna of *V. (Ventidius) malayensis* sp. nov.
4. The male front leg of *V. (Ventidius) usingeri* sp. nov.
5. The male front leg of *V. (Ventidius) malayensis* sp. nov.
6. The left paramere of *V. (Ventidioides) kuiterti* sp. nov.
7. The right paramere of *V. (Ventidioides) kuiterti* sp. nov.
8. The left paramere of *V. (Ventidius) henryi* sp. nov.
9. The left paramere of *V. (Ventidius) chinai* sp. nov.
10. The left paramere of *V. (Ventidius) usingeri* sp. nov.
11. The right paramere of *V. (Ventidius) werneri* sp. nov.
12. The left paramere of *V. (Ventidius) malayensis* sp. nov.

PLATE III


MESONOTUM
INTERSEGMENTAL SUTURE
METANOTUM
LATERAL SUTURE
1ST ABD SPIRACLE
1ST ABD. SEGMENT
1
Esakia usingeri
2
Hypothetically primitive Ventidius species
3
4
5
6
7
8
9
10
11
12

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A Revision of the Mite Family Bdellidae in North and Central America (Acarina, Prostigmata)

BY

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ABSTRACT. This study, although primarily a monographic revision, includes data on the bionomics, morphology, and intraspecific variation of the bdellids. Eleven genera are recognized, including a new genus *Octobdellodes;* four genera or subgenera are synonymized, these are: *Cacnobdella* Oudemans, 1937 (= *Bdella*), *Troglobdella* Oudemans, 1937 (= *Cyta*), *Hoplomolgus* Berlese, 1923 (= *Neomolgus*), and *Hoploscirus* Thor, 1937 (= *Bdellodes*).

Thirty-two species are included in this paper, of which sixteen are new. Four species are moved to other genera, and thirteen species, for which type materials are available, are synonymized. For other synonymies, Thor (1931) is recognized.

The sixteen new species described are: *Bdella longistriata, B. tropica, Bdellodes bisctosa, Cyta spuria, Neomolgus mutabilis, Octobdellodes hurdi, O. infrequens, Odontoscirus iota, O. alphinus, Thoribdella communis, T. insolita, T. simplex, T. spinosa, T. communis, Spinibdella bifurcata, S. ornata.*

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INTRODUCTION

The purpose of this study has been to develop a solid basis for the systematics of the family Bdellidae. Inadequate descriptions, loss of types, and conflicting impressions of the type genus *Bdella* often make it wholly impossible to determine which of the previously proposed species are valid.

Of the twenty-five hundred specimens examined, approximately twenty-one hundred were from Central and North America, two hundred from Iceland, one hundred from Australia, one hundred from Europe, and less than five from each of the continents South America, Asia, and Africa. Although over one hundred species and eighteen varieties have been described in the literature, only twenty named species were discovered, of which, sixteen occurred in Central and North America. Thor (1931) synonymized many species with those that appeared to him to be valid. Thor's synonymies will not be questioned in the present investigation, which, due to the lack of abundant European material, is necessarily restricted in scope.

To clarify my position in the taxonomy and systematics of this group, detailed descriptions and illustrations have been introduced for the known species of Central and North America, which number sixteen named and sixteen new species.

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COLLECTION OF MATERIAL

It is desirable to collect and preserve these mites in such a way as to avoid contamination with fine particles of dirt and sand. Both of these substances readily adhere to the integument and, even with drastic clearing methods, so much accumulation may remain on the specimen that even generic determinations are difficult.

Berlese funnels efficiently extract bdellids from litter, soil, nests, and compact plants, such as mosses and foliose lichens. Water is superior to alcohol in the Berlese collecting vial. The high surface tension of water, as compared to alcohol, will support many of the mites on the surface while permitting soil particles to sink. With a small brush or spatula, the mites can be transferred to a preservative with a minimum of extraneous matter.

To collect from moss, lichens, and other miscellaneous epiphytes *en situ*, one can beat the material over a white enamel pan and remove the dislodged mites from the pan with a small brush. Similarly, individual mites can be removed from rocks, boards and other relatively large and smooth surfaces.

Habitat specificity has not been demonstrated in the Bdellidae, although this may be due to a lack of data that would mask the character of the true situation in this regard.

PREPARATION OF MATERIAL

Two satisfactory media for mounting bdellids, which are soft-bodied mites, have been used. These are polyvinyl alcohol with lactic acid and phenol added (PVA-L-P) and Hoyer's modification of Berlese's mounting medium (see Beer, 1954, for formulations). Comparing these two media, each has certain advantages and disadvantages. PVA-L-P has less clearing action and it is less difficult to prepare specimens in which appendages are in the same horizontal plane, but to remount from this medium is an extremely hazardous undertaking with specimens having a soft integument. Hoyer's clearing properties are excellent for smaller uncleared bdellids, causing little distortion in striations, shape or size. Although

slightly more difficult to use than PVA-L-P, the ease with which specimens can be remounted without the loss of or damage to parts is an advantage that cannot be over-emphasized.

Characters necessary for specific determinations are located on both the dorsal and ventral surfaces of the body. For this reason, large and opaque specimens must have their body contents removed or thoroughly cleared before mounting. Other specific characters are found on the surfaces of the legs and palps. For easy study, it is therefore desirable to have these appendages similarly oriented and extended in the same horizontal plane. Heating of specimens in lacto-phenol at 200° to 250° F. for a short time will soften the leg muscles sufficiently to allow easy manipulation of these appendages and further heating in lacto-phenol slightly under the boiling point (up to 400° F. after moderate evaporation) will dissolve the body contents. The time required for the latter process is variable, depending on the size of the specimen and the type of preservative. Potassium hydroxide, although used as a clearing agent in many groups, is not a satisfactory reagent for bdellids as its drastic action causes a considerable loss of diagnostic setae.

Specimens used for the study of musculature were prepared by a different process. Bdellids, previously preserved in ninety-five per cent alcohol, were cleared in beechwood creosote for five to ten minutes, then transferred directly to thin balsam. The palps and legs were removed from the body with small needles and placed in the mounting medium. A cover slip, first immersed in xylene, was gently pressed against the specimen until the appendages were in the same horizontal plane.

GEOGRAPHICAL DISTRIBUTION

Mites of the family Bdellidae have been collected from all major land masses of the world and from many insular groups. When distribution records are more complete, many species will probably be found to be cosmopolitan in distribution. Many of the species found in the Western Hemisphere are also found in other parts of the world. One species is known to occur in North America from Mexico to Alaska, as well as in Iceland and Europe. One species has been collected in China, Australia, Hawaii, and North America. Another species is circumpolar in distribution.

BIONOMICS

Bdellids are active, fast-running mites, predaceous on small arthropods and arthropod eggs. They seem to occur in almost every terrestrial habitat where food material is available. Three investigations on the biology of these mites have been reported. Womersley (1933a) and Currie (1933) studied one species as a possible biological control agent for the clover springtail or lucerne flea (*Sminthurus viridis* L.) and Snetsinger (1956) studied the biology of *Spinibdella depressa* (Ewing).

Species observed in temperate regions apparently have broad temperature and humidity tolerances. Although specimens are most frequently collected in moist, cool habitats, this may be a consequence of the availability of food animals. Many individuals have been collected from dry, exposed surfaces, and Bornemissza *(in litt.)* has evidence indicating that a *Cyta* species may be restricted to the desert regions in Australia. On the other hand, Snetsinger (1956) could obtain complete life histories only at ninety per cent relative humidity between sixty and seventy degrees Fahrenheit.

Bdellids in temperate climates overwinter in all stages of development. In Kansas, the author has collected all the active stages of local *Cyta* and *Bdella* species from leaf litter as early as February 22, and although the deutonymphal and tritonymphal stages were the most prevalent, the larvae, protonymphs, and adults were also present. Snetsinger (1956) observed that in Illinois the egg stage is the most abundant overwintering form of *Spinibdella depressa,* but all stages except the larval stage were found hibernating under tree bark.

These mites have the life history stages found in many trombidiform mites, that is, egg, deutovum, larva, three nymphal stages, and adult. Each active immature stage ends in a period of quiesence, following which the old integument is shed. Currie (1933) reported that one nymph of *Biscirus lapidarius* consumed eighteen immature clover springtails on each of three successive days, and Snetsinger (1956) reported that immatures of *Spinibdella depressa* require three or more tetranychid mites to complete each developmental stage. The latter author also found that the length of time necessary for development is partially dependent on temperature, lengthening as the temperature decreases. Development from larva to adult at ninety percent relative humidity required twenty-one to thirty days at sixty degrees Fahrenheit, but only fourteen to twenty-one days at seventy degrees.

Oviposition preferenda have not been reported; however, there is a tendency for the females to lay eggs in protected areas. In stender dishes coated with a plaster-of-paris and charcoal mixture (Lipovsky, 1953) and marked with a deep line to simulate a crack, the author observed the sites of egg deposition of four females. Sixteen spiny elliptical eggs, laid singly at the rate of one egg each one and one-half days, were deposited in the prepared crevice at the bottom of the dish, while only one egg was laid in an exposed area near the wall of the dish. In the field, Snetsinger (1956) found that large numbers of eggs were deposited during the autumn months under the basal bark of trees, probably a result of females aggregating in protected spots at the onset of cold weather.

Parthenogenesis has not been discovered in the Bdellidae. Although the forty-five specimens of *Bdella trop'ca*, sp. nov. and one hundred and forty-six specimens of *Spinibdella cronini* examined in this study were all females, this cannot be construed as proof of parthenogenetic development. In all species for which large numbers of specimens were available, there were usually many more females than males. For example, there were one hundred and fifty-six females and forty males of *Bdella longicornis* and ninety-two females and only four males of *Bdella muscorum*. The sexes were approximately equal in number only in *Bdellodes longirostris*, of which forty-eight females and forty-four males were examined. Occasionally in small collections of two to ten specimens of the three latter species, all or most of the individuals were males. Plausible explanations for the scarcity of males, especially for *B. tropica* and S. *cronini*, could be that the sex ratio is extremely unequal; that the males have different habitat preferences; or that they have different peaks of seasonal abundance.

Personal observations on feeding habits were made by the use of covered stender dishes with collembola as the food source. Bdellids, when placed with collembola, move slowly until contact is made with the distal setae of the palpi. If the mite is startled, it will run rapidly backwards. If not startled, the mite will lunge at the prey, impaling it on the tips of the mouth parts. The chelicerae are rapidly and alternately extended and retracted at various angles into the body of the prey, while the chelae are opened and closed, thus macerating the tissues. If disturbed while feeding, the bdellid elevates the tip of the gnathosoma with the mouth parts still inserted in the prey, and in this fashion the mite may move away from distracting influences. When feeding is completed, the mite either goes to a secluded spot or again moves slowly about the dish.

MORPHOLOGY

General

The general body configuration of the bdellids has been known for many years. Geoffroy's (1762) drawing of *Bdella longicornis*, even with its inaccuracies, can easily be recognized as belonging to this family. The knowledge of the external morphology has increased with better optical equipment, culminating with Grandjean's (1938) investigation. The internal morphology is known only from Michael's (1896) study of the internal anatomy of *Neomolgus littoralis* (= *Bdella basteri* Johnston, 1836).

The body is divided into three distinct regions, the gnathosoma, propodosoma, and hysterosoma. The anterior gnathosoma consists of two elongate, chelate chelicerae (mandibles of authors), a ventral hypostome (rostrum of authors), and two geniculate palpi. Collectively the chelicerae and hypostome form a conelike structure projecting from between the palpal bases. The propodosoma bears the two anterior pairs of legs, eyes, and pseudostigmatic organs, this region being delimited dorsoposteriorly by a conspicuous constriction. The hysterosoma bears the posterior legs, anus, and genitalia.

Segmentation of Appendages

In order to determine the possible homologies between the legs and the palpi, it is necessary to establish basic relationships in the more primitive of the two types of appendages, the legs. Bdellid larvae have seven-segmented legs (including the pretarsus), lacking the division between the basifemur and the telofemur. The division of the femur is barely perceptible in the anterior three pairs of legs in the protonymph; but each succeeding instar exhibits a progressively more-distinct femoral division in all legs. Camin has prepared diagrammatic illustrations of the musculature of the legs and palpi (figs. 3-5). According to Camin's forthcoming theory (in manuscript), he believes that, primitively, each primary segment of the leg had two flexor muscles which insert on the succeeding segment. In bdellids, the three distal segments have undergone considerable change and may not represent the primitive genu, tibia, and tarsus, but for convenience they will be denoted by the standard terminology in this paper. The primitive condition is best demonstrated in the femur which has two flexor muscles (fig. 3, *a, a*) inserted at the base of the genu. An advanced feature, the ventral flexor muscle of the telofemur may be a branch of the proxi-

mal flexor of the genu, the insertion of which has migrated. The undivided femur in the larva and the lack of muscles inserting on the telofemur in all developmental stages suggest that the telofemur is not a primary segment but a secondary subdivision of the femur allowing additional flexibility of the legs.

Previous workers have referred to the three distal segments of the palpus as the genu, tibia, and tarsus. Although the musculature of the palpus is greatly reduced, it is possible to homologize the palpal segments with the segments of the leg, thus demonstrating that these segments represent the telofemur, genu, and fused tibiotarsus. The femur, partially divided into basi- and telofemur, has two long flexor muscles (fig. 5, *a, a*) homologous to flexor muscles in the legs; the small extensor muscle (fig. 5, *f*) has no homologue in the legs. Two muscles inserting at the base of the distal segment, with origins in the penultimate segment and telofemur, can be homologized with the flexors of the tibiae of the legs. The penultimate segment of the palpus can therefore be homologized with the genu of the leg. The distal palpal segment, lacking muscles and pretarsal elements, represents the remaining segments, the tibia, tarsus, and pretarsus. In the Cunaxidae, the musculature of the palpus (fig. 6) is similar to that in the bdellids, but there is an incomplete fusion of the tibia and tarsus.

Setae

Two general types of setae are abundant: thick-walled (tactile) setae and thin-walled (chemosensory) setae. The tactile setae ("Eigentlichen Haare" of Vitzthum, "Poils proprement dits" of Grandjean) are inserted in alveoli, are movable, tapering, nude or plumose, and have extremely small lumina. The chemosensory setae ("solenidions" of Grandjean), for convenience termed sensory setae, are inserted in small pits or depressions lacking alveoli; they are fixed, nude or minutely pilose, and have large lumina. Commonly, the form of the thin-walled setae is slender and tapering (attenuate) (fig. 189), or thick and broadly rounded distally (fig. 188). The tips of both forms curve away from the body. In bdellids, the sensory setae are not striated as in many other groups of prostigmatic mites. Sensory setae are restricted to the four distal segments of the legs except for one on the palpal tibiotarsus.

The long apical setae of the palpal tibiotarsus, which are tactile in function, have two types of insertions. In *Cyta* and a few species of *Bdella* and *Spinibdella,* the setae originate deep within the seg-

ment; in the other genera studied, the apical setae are slightly enlarged at their bases and inserted in superficial sockets. Commonly in the Odontoscirinae, the edges of the apical sockets are heavily sclerotized and form distinct rims.

The four sensilla, although of variable lengths and diameters, are long and tapering (except *Thoribdella*) and each is inserted in a pseudostigmatic organ. In the genus *Thoribdella*, the posterior sensilla vary from short thin setae to short thickened rods which are divided in the middle into three connecting arms (fig. 150).

A third type of seta is short and peglike and has a variety of shapes and forms (figs. 190-193). Solid pegs, possibly blunt spines, are found on the dorsolateral rims of coxae I and II (fig. 2, *f*) and on the dorsolateral regions of the hypostomal bases in close proximity to the cheliceral bases ("L'épine latérocoxale du palpe" of Grandjean). The positions of these three pairs of setae suggest that they function as proprioceptors. Other pegs, maximally one on each of the two distal segments of legs I and II, are inserted in pits, lack alveoli, and may represent highly modified chemosensory setae.

Chaetotaxy of the Legs

The chaetotaxy of the legs provides important taxonomic characters. The majority of the leg setae are tactile, and sensory setae and pegs occur only on the dorsal surfaces. Tactile setae are arranged on the legs as follows: two or more rows of ventral setae that tend to be plumose on the tarsi; one row each on the anterior and posterior (lateral) surfaces, and one to three unpaired setae on the dorsal surface of each segment except the coxa.

The majority of the sensory setae occur on legs I and II, with leg I having the greater number. Tarsus I has two, occasionally three, broadly rounded sensory setae (fig. 188), two or more attenuate sensory setae (fig. 189), and usually one peg (figs. 190-193). Tarsus II usually has the same number of blunt sensory setae and pegs, but fewer attenuate sensory setae than tarsus I. The proximal halves of tibiae I and II have only attenuate sensory setae, but the distal portions may have any combination of the various types of specialized setae. The tibiae and tarsi of legs III and IV have only the attenuate type of sensory setae.

Duplex setae similar to those found in the Tetranychidae (Prichard and Baker, 1955) and/or attenuate sensory setae are inserted on the genua. When duplex setae are present, they occur on the anterior three genua, but may be wanting on genu IV. The inser-

tions of the micro- and macrosetae that comprise a duplex seta may be confluent, separate and approximate, or separate and distant (figs. 194-197).

The number of tactile setae may vary considerably within a species, as is the case with the attenuate sensory setae on the genua and proximal halves of tibiae I and II. The other types of sensory setae are usually constant in number, but may vary in position (see p. 365).

Trichoboths (long tactile setae) are inserted in deep, heavily sclerotized sockets (fig. 184) and are similar in structure to the dorsal sensilla. The maximum number of trichoboths is five pairs, which are inserted on tibiae I, II, and IV and tarsi III and IV. The subfamilies are characterized, in part, by the number of trichoboths present in the adult stage. The Odontoscirinae have five pairs arranged as above; the Spinibdellinae and Bdellinae have four pairs, lacking the trichoboth on tibia II (*Bdella mexicana* also lacks the trichoboth on tarsus IV); and the Cytinae have less than four pairs. In the latter subfamily, trichoboths are inserted on tibiae I and IV and tarsus III except *Cyta latirostris* which has only one trichoboth inserted on tibia IV. In species with less than five pairs of trichoboths there is a large tactile seta in the position normally occupied by a trichoboth when compared with the Odontoscirinae.

The larvae of all species studied (except *Cyta latirostris*) have one trichoboth which is inserted on tarsus III; the protonymphs have the same number of trichoboths as the adult on the anterior three pairs of legs, but leg IV has none; succeeding instars have the adult number on all legs. *C. latirostris* is an exception, having one trichoboth inserted on tibia IV in the tritonymphal and adult stages, the other instars lack trichoboths.

The extremities of all the tarsi are abruptly narrowed subapically where the dorsal tarsal surfaces bend sharply downward to the pretarsus. On each of the oblique surfaces thus formed are three pairs of setae which constitute the dorsoterminals. The proximal pair of dorsoterminals (*dt 1*) are long and curve obliquely from the claws (leg IV may have only one seta in this position). The second pair (*dt 2*) is inserted midway between *dt 1* and the pretarsus, and the distal pair (*dt 3*) flanks the pretarsus. The two distal pairs (*dt 2, 3*) extend to the bases of claws and are present in all known species except *Biscirus silvaticus* which lacks one of the middle pairs of setae. The dorsoterminals may be thick-walled (termed solid) or thin-walled (termed hollow) and may be nude to coarsely branched

(figs. 179-183, 185-187). Although different forms may occur on different legs, the structure of the dorsoterminals is usually constant within a species. Generally, thin-walled setae on the anterior legs are replaced by thick-walled setae on the posterior legs.

The short pretarsus, indistinctly divided on its dorsal surface into three pseudosegments, arises between *dt* 3. The distally inserted claws may have one, two, or no small dorsal ridges bearing laterally directed rays (fig. 70). These rays may be long and few in number or minute and numerous. In the latter case, the small rays are designated as the minute rays. Only the size of the claws and the presence or absence of lateral and/or minute rays were found to be of taxonomic value.

Gnathosoma

The gnathosoma, consisting of the elongate chelicerae, hypostome and palpi, is one of the most characteristic features of the Bdellidae. The geniculate palpus has six segments: coxa, trochanter, basifemur, telofemur, genu and tibiotarsus, the latter bearing apically one or two long tactile setae. The coxa is fused with the base of the hypostome, and thus is indistinguishable as a separate segment. The trochanter is small and devoid of setae. The femur is incompletely divided into a long proximal basifemur and a short distal telofemur. The basifemur bears a variable number of setae, but the telofemur has only one seta that is always inserted on the dorsal surface. The genu may be as long or longer than the telofemur and bears two to seven setae. The terminal, fused tibiotarsus varies greatly in length and shape. Typically, the tibiotarsus is approximately the length of the genu plus the telofemur, is expanded distally, and obliquely truncated at the apex; or it may be more than twice as long as the genu plus the telofemur, cylindrical, and apically rounded. Unfortunately, there are many intergrades between these two readily recognized conditions, thereby making size and shape of the palpal tibiotarsus a highly subjective character in many instances.

The dorsal and ventral apical setae resemble the trichoboths of the legs and the dorsal sensilla. In the Odontoscirinae, the end setae are approximately equal in length and shorter than the cylindrical tibiotarsus. In *Monotrichobdella,* there is a single apical seta. In the remaining genera, the end setae are subequal and usually much longer than the tibiotarsus.

In life, the geniculate palpi are flexed at the two distal articulations and are carried extending forward and bowed upward. In slide preparations, especially with cleared specimens, the medial or

lateral aspects are most frequently encountered. Two useful points for determining orientation of the palpus are the relative positions of the dorsal and ventral end setae and the position of the single dorsal seta of the telofemur.

The chelicerae are elongated and bear movable chelae. The number and position of setae, the shape of the chelicerae, and the form of the chelae are sufficient to distinguish many genera.

The majority of the genera have normal chelicerae which are approximately three to five times as wide at their thickest portion as at their thinnest, and have chelae with small sickle-shaped movable digits and small straight fixed digits (figs. 7-8). The inflated chelicerae of a few species of *Odontoscirus* and *Bdella* (figs. 13, 16) are more than five times wider at the base than at their narrowest parts. In *Odontoscirus* the inner surface of the movable digit is straight if the teeth are disregarded (figs. 9, 16, 17). A third cheliceral shape occurs in the Spinibdellinae (figs. 32-35) which has a narrow form with almost parallel sides and needlelike chelae (fig. 10). The genus *Cyta* is unique in having large, thickened chelicerae (figs. 30-31) tipped with massive chelae (fig. 11). One or more teeth may be present on the inner surfaces of the fixed digits.

Two setae are inserted on the dorsal or dorsolateral surfaces of the chelicerae in most genera. *Cyta* has two setae on each chelicera, but one is inserted at the base of the fixed digit (fig. 11); *Neomolgus* has more than two setae; and *Bdellodes longirostris* and one undescribed species of *Thoribdella* from Australia have only one seta on each chelicera.

Viewed from the ventral aspect, the gnathosoma has three distinct regions (fig. 2): a transversely striated, rectangular base bearing the palpi at the anterolateral angles; a long, gently tapering buccal cone; and two small, terminally fringed lateral lips which are separated from the buccal cone by a weak suture. The rectangular gnathosomal base consists of the palpal coxae fused with a basal portion of the hypostome, and the buccal cone and the lateral lips represent the major region of the hypostome.

The setae inserted on the gnathosoma can be best characterized by their positions. The ventral hypostomals (*vh* series) are on the ventrolateral surfaces of the buccal cone and the anterior margin of the hypostomal base. In adults, either two, six, or seven pairs of these setae are present. Two pairs of small adornal setae inserted on the lateral lips are present in all the developmental stages. Finally, one pair of setae may be present on the dorsal surface of

the hypostome; when present, these setae are covered by the bases of the chelicerae ("les poils prémandibulaires" of Grandjean). When characteristic for a species, these dorsal hypostomal setae occur in all the stages of development.

In genera with six or seven pairs of ventral hypostomal setae, the immature stages may be identified by the number of setae present. The larvae have two pairs; the deutonymphs, four pairs; and the tritonymphs have five pairs. The Cytinae and Spinibdellinae have two pairs of ventral hypostomal setae in all stages.

The dorsum of the propodosoma has a thicker integument than the remainder of the idiosoma. A uniform thickening on the inner surface has developed which is approximately rectangular to reniform in shape, and encompasses the four pseudostigmatic organs ("shield" of authors). This thickening of the integument attains greatest development in the Odontoscirinae.

Internal ridges or apodemes connecting the pseudostigmatic organs laterally and sometimes anteriorly have developed secondarily in a few species. In their simplest form, the lateral apodemes are narrow with parallel margins (fig. 140). More complex forms, as in *Bdella longicornis*, have smaller thickenings mesal or lateral to the prominent lateral apodemes which form an interlacing network of supporting structures (figs. 133-135).

Two pairs of sensilla are inserted in the pseudostigmatic organs. In all the genera except *Thoribdella*, the pseudostigmata are cup-like sockets lined with concentric rings of small ridges and often are heavily sclerotized. In *Thoribdella*, the posterior pseudostigmata (figs. 142-149) are deep, goblet-shaped cavities of thin integument, lined with finely divided ridges which are perpendicular to the insertions of the sensilla.

A pair of median propodosomal setae (fig. 1) is always present between the posterior sensilla. In structure, these setae resemble the dorsal hysterosomal setae. Another pair of setae, the lateral propodosomals, may or may not be present. If present, they are inserted lateral to a line connecting the lateral sensilla. In structure, the lateral propodosomals are usually simpler than the median propodosomal setae.

The integumental striae between the dorsal sensilla form distinctive shield patterns. A particular pattern may be unique to a species, or as in the Odontoscirinae, a pattern may be common to many species. Each striation is a sharp ridgelike external thickening of the integument with small breaks along the crest. In micro-

scopic examination, the breaks cause the striae to appear finely broken (fig. 133), coarsely broken (fig. 156), or sparsely broken (fig. 136).

The eyes are lateral or posterolateral to the posterior sensilla. Two pairs are usually present, and the eyes of each pair may be approximate to distant. One species, *Spinibdella depessa*, has the posterior eyes wanting, but their former positions are indicated by teardrop patterns of the striae. In addition to the lateral eyes, *Cyta* has a fifth eye between the anterior sensilla (fig. 165). A fifth eye or protuberance in a similar position was reported by Baker and Balock (1944) in their original description of *Monotrichobdella maxosburni*, but this could not be distinguished in the remounted type specimen.

The podocephalic canal (Grandjean, 1938) could not be adequately examined in specimens mounted in Hoyer's or PVA-L-P. Grandjean describes this canal as being an external groove in the integument or an internal tube which originates on each side of the dorsoposterior surface of the buccal cone, follows the contours of the lateral body wall, and terminates above coxa I. Three tubular glands of unknown function open into the canal: one near the laterocoxal spine of the palpus, one at the junction of the idiosoma and the gnathosomal base, and one close to the termination of the canal above coxa I.

Dorsal Hysterosoma

The dorsum of the hysterosoma has five transverse rows of setae (fig. 1). Using the nomenclature of Oudemans (*fide* Vitzthum, 1943), these setae are:

1. internal and external humerals
2. internal dorsals
3. internal lumbrals
4. internal and external sacrals
5. internal and external clunals

The sacrals and clunals are arranged in gently to strongly curved, transverse rows, or in extreme modifications, in a subrectangular arrangement. In a few species, the external clunals are wanting. The hysterosomal setae are nude to plumose and are usually constant in form within a species. In a few species the form varies in populations from different geographical areas. The longitudinal intervals between the internal humerals and the internal dorsals, the first interspaces, are used as a relative measurement of the lengths of the internal humerals.

Anal Region

The posterior anal cleft is surrounded by striae (border striae) which either parallel the entire length of the cleft or are parallel to approximately the center of the cleft, then bend sharply laterad. The setae of the anal region (figs. 1, 2) differ from the dorsal hysterosomals in being shorter, thinner, and usually nude. One or more pairs of setae situated in the region of the parallel striations are considered to be the anal setae, or anals. One pair of setae near the dorsal termination of the anal cleft is termed the posterior paranals, or postanals. Other setae, lateral to the anals are the paranals.

Genital Region

Two longitudinally striated genital plates or flaps are situated on the venter of the hysterosoma between the anal cleft and coxae IV. Each plate bears a regular or irregular row of genital setae which may vary slightly in position and number within a species. The area surrounding the genital plates has bilaterally arranged pairs of paragenital setae (figs. 2 *g*, 178 *b*). In the Cytinae, there is an unpaired median seta immediately anterior to the genital plates (fig. 178 *c*). Species of *Spinibdella* may have unpaired setae, but they occur between coxae IV.

When the genitalia are in repose, a chamber or vestibule is formed above the genital plates, the walls of which are contiguous with the mesal edges of the plates. Three subequal genital discs, each with a small spine of unknown function immediately caudad, are on the lateral walls of the vestibule.

Because of the method of preparation, only sclerotized portions of the genitalia remained for examination. The ovipositor is a large membraneous tube which can be telescoped into the body or wholly extruded. When in the latter position, the genital discs are carried outside the body and are at the base of the ovipositor. Slightly distal to the mid-length as many as four pairs of postmedial setae may be present, and surrounding the tip of the ovipositor there are six to ten pairs of subapical setae. A transverse cleft bisects the apex, and two small, heavily sclerotized structures, probably glands, are internal to the angles of this cleft.

The male genitalia are more complicated. In the pair of large sclerotized plates, the amphioid sclerites (Michael, 1896), each has the lateral edge bent dorsad to form a dorsal arm. Simple to highly modified setae form an irregular series along the periphery of each

amphioid sclerite (figs. 169-177). The penis is a thin muscular organ surrounded by a loose membranous sheath (Michael, 1896). During copulation, the amphioid sclerites are everted, thus placing the dorsal setae in a ventral position in contact with the exterior. Evidently, the penis is connected to the dorsal arms of the sclerites and carried outward with the eversion of these sclerites.

Specific differences in the male and female genitalia exist, but only the males of *Spinibdella* and *Cyta* have differences striking enough to warrant their use as a taxonomic character at this time. Although males were present for only three species of *Spinibdella,* the bizarre modifications of the amphioid setae appear to be specific and stable characters. The setae of the three *Cyta* species lack unique shapes, but have different arrangements and lengths. In other genera, the setae lining the amphioid sclerites are similar in structure, the slight differences in length and position could not be evaluated. Differences in the female genitalia are slight and can be detected only if the ovipositor is almost wholly extruded, a condition of rare occurrence.

Genital tracheae, present in the Spinibdellinae and Cytinae, open into the genital vestibule in front of the anterior pair of genital discs (fig. 178 *d*). These paired structures are round and have spiral thickenings which resemble the taenidia of insect tracheae (except *Trachymolgus,* see below). The genital tracheae of the Cytinae each have a single dichotomy near the origin, one branch leading to the anterior tracheal opening near the cheliceral base, the other branch ending above coxa I. In the Spinibdellinae, the tracheae lack dichotomies; a single branch on each side of the body ends above coxa II. Relatively large, flat platytracheae, which are expanded at their distal terminations, originate in the anterior region of the genital vestibule and end above coxae II in *Trachymolgus* (Grandjean, 1938).

Immature stages can be distinguished by the number of genital setae and genital discs. Protonymphs have one pair of genital discs, deutonymphs have two pairs, and tritonymphs and adults have three pairs. Genital setae also increase in number in the progressive instars; protonymphs have one pair (*Biscirus silvaticus* has none), deutonymphs have two pairs (*Cyta latirostris* has one pair), tritonymphs have four to eight pairs, and the adults possess more genital setae than their respective tritonymphs.

SYSTEMATIC RELATIONSHIPS

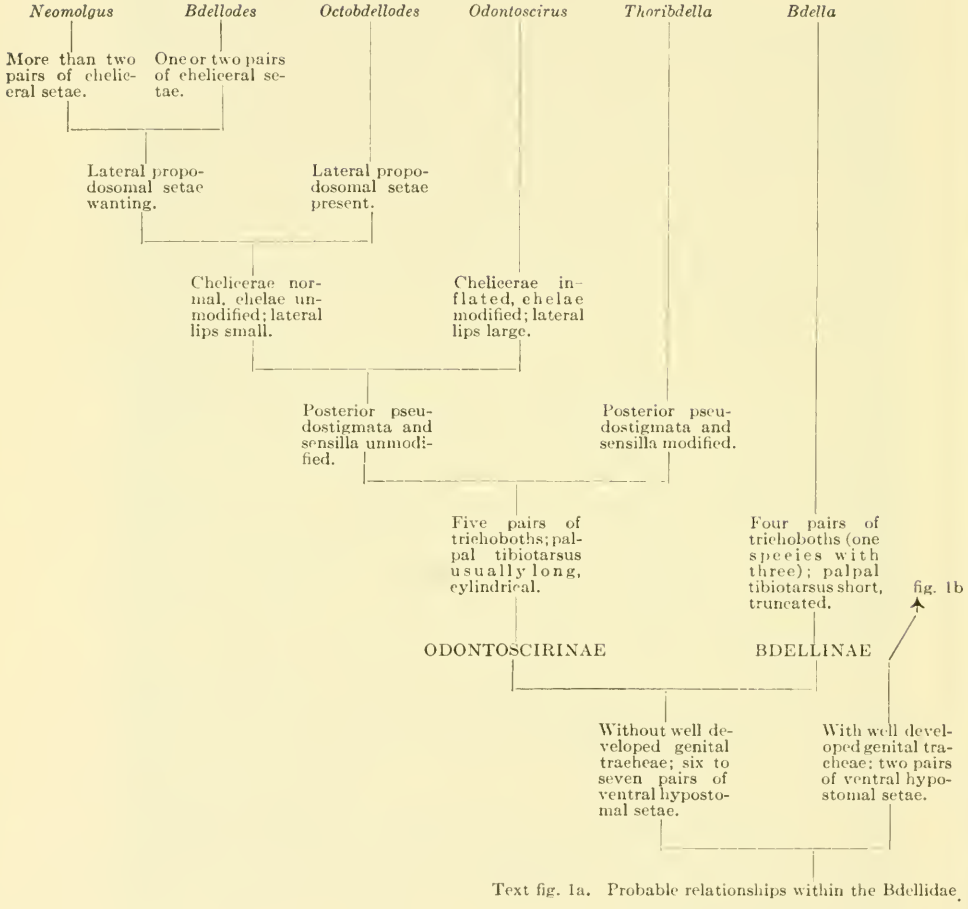
Except for occasional oversights, there has been little question among acarologists as to what constitutes the group commonly known as the "snout mites." These mites have been identified as being soft-bodied, predaceous mites with an elongated, conelike gnathosoma, chelate chelicerae, and long, modified palpi. In 1902, Thor divided the Bdellidae, erecting a new family, the Cunaxidae, for "snout mites" with palpi modified for grasping prey and retaining the name Bdellidae for the remainder of the group.

Until recently, bdellids could be easily differentiated from cunaxids by the presence of one or two long, tactile setae at the apices of the palpi. Although this character has been shown to occur in at least one species of Cunaxidae (Atyeo, 1958), the families Bdellidae and Cunaxidae still seem separable and the present paper deals only with the former.

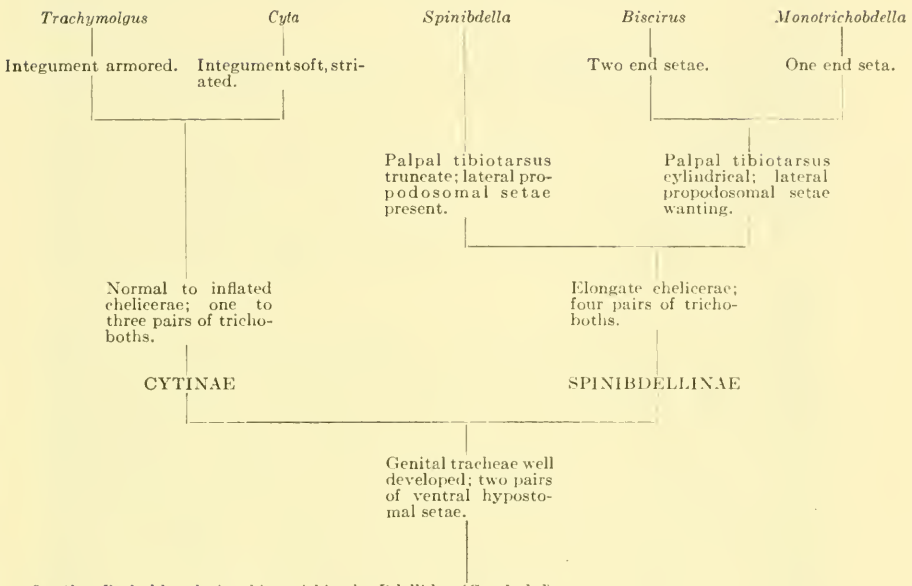
Bdellids are characterized as having well developed, chelate chelicerae; padlike, rayed empodia; five-segmented, tactile palpi; two, four, or five eyes; finely striated integument (except *Trachymolgus*); three pairs of genital discs; and usually more than one pair of trichoboths. Cunaxids have chelicerae with the fixed digit wanting; empodia reduced to a few rays; three to five-segmented palpi usually modified for grasping prey and usually armed with strong spines or apophyses; eyes present or wanting; integuments usually with nonstriated plates; two pairs of genital discs; and one pair of trichoboths.

In attempting to determine the probable relationships within the Bdellidae, the genital tracheae and the ventral hypostomal setae seem especially important. Two major groups can be recognized, one with well developed genital tracheae and two pairs of ventral hypostomal setae, the other without well developed genital tracheae and with six to seven pairs of ventral hypostomals. Within these two groups Grandjean (1938) placed genera showing strong affinities into four subfamilies (see key, p. 371) which appear to be natural groups.

Except for *Odontoscirus* and the species of *Bdella* having inflated cheliceral bases, the shape of the chelicerae, the position of the cheliceral setae (except *Neomolgus*), and the unmodified chelae are identical in both the groups lacking genital tracheae, the Odontoscirinae and the Bdellinae (text fig. 1a). In the subfamilies with genital tracheae, the chelicerae are either elongated and have



Text fig. 1a. Probable relationships within the Bdellidae.



Text fig. 1b. Probable relationships within the Bdellidae (*Concluded*).

needlelike chelae (Spinibdellinae) or are greatly thickened with massive chelae (Cytinae, except possibly *Trachymolgus*), and the anterior cheliceral seta is inserted on the distal fourth of the chelicera.

Only a few characters are available for generic separation (text figs. 1a, 1b). Although genera separated on these characters appear to form natural groups, one difference does occur that cannot be evaluated. In the Odontoscirinae, only three species have lateral propodosomal setae; *Octobdellodes* gen. nov. has been erected to include two of these species. The third undoubtedly belongs to *Thoribdella*, as it has highly modified posterior sensilla. Except for this single species of *Thoribdella*, the presence or absence of the lateral propodosomal setae is a stable generic character, therefore, the exact significance of one anomalous species cannot be ascertained.

Internal apodemes on the dorsal propodosoma occur in species of the Bdellinae and the Cytinae. The large rectangular to reniform-shaped thickening of the integument varies according to the species in all groups, but it is best developed in some members of the Odontoscirinae. Cuticular deposition can only be considered to be a continuum, the amount seen in any species depends not only on the individual, but also on the optical equipment, the method of clearing the specimen, and the nature of the mounting medium. *Hoploscirus* Thor, 1937 and *Hoplomolgus* Berlese, 1923 were erected for species of *Bdellodes* (= *Scirus*) and *Neomolgus* (= *Molgus*) in which the reniform thickenings (dorsal shields of authors) could be readily detected. The distinguishing character for both genera is apparently based on an extreme modification of a continuous character, cuticular deposition.

An increased number of cheliceral setae appears only in *Neomolgus* and previously, *Bdellodes* has been considered to be the only genus having one cheliceral seta. However, this character is not sufficient to distinguish *Bdellodes*, as members of this genus have been discovered with two cheliceral setae, and in undescribed species of *Thoribdella* from Australia, the posterior cheliceral seta is vestigial in one species and wanting in another species.

A similar modification of the lateral lips of the hypostome occurs in both major groups of bdellids. In *Cyta* and *Odontoscirus*, these structures are prominent and heavily fringed apically. In other genera, the lateral lips are small and the cuticular fringe is minute (fig. 2).

INTRASPECIFIC VARIATION

A preliminary investigation of intraspecific variation demonstrated a constancy of characters, especially within local populations. Although evidence for subspecies exists in some species, until more extensive material has been gathered, it is judged advisable not to name them.

The variation found in species of wide distribution is striking. There appears to be a positive correlation between increase in body size and decrease in temperature. Generally the larger species or individuals of a given species of *Cyta, Bdella* and *Neomolgus* occur in the colder regions. Concrete data on this apparent geographical variation is presented under a few of the widespread species for which series from widely separated localities are available.

A few characters, such as striation patterns and gnathosomal structures may be unique for a species, or may be similar in more than one species. The definitive character for species differentiation appears to be the number, type and relative positions of the sensory setae of the legs. Except for the attenuate sensory setae located on the dorsal surfaces of the genua and proximal halves of the tibiae, specialized setae are extremely stable. Although these setae tend to be in slightly different positions in each specimen, their relative positions are the same. To illustrate this phenomenon, the positions of the sensory setae on tarsus I were plotted for thirty-eight specimens of *Bdella longicornis.* In figure 71, the stippled area surrounding the bases of each seta represents a composite of all the positions in which the seta occurred. Generally, all the setae migrated either up or down the tarsus, thus, even though the exact positions had changed, each seta was approximately in the same relative position to the other sensory setae.

TAXONOMY

Historical Account

Excellent historical accounts have been presented by Thor (1931), Oudemans (1937), and Vitzthum (1931a). This discussion will therefore be limited to the important systematic questions that have been created in the past.

Latreille (1795) originally described the type genus *Bdella* as having "Deux antennules filiformes, longues, coudées, de quatre articles, dont le premier et le dernier fort longs: celui-ci terminé par deux poils. Trois valvules réunies, formant un bec advancé, alongé et conique . . ." "*La pince rouge*" Geoffroy, 1762, was selected

by Latreille for the type species and the description was based primarily on Geoffroy's illustration. In the following year, Latreille (1796) synonymized "*La pince rouge*" Geoffroy, 1762, with *Acarus longicornis* Linnaeus, 1758. Controversy arises in the interpretation of the relative lengths of the two longer palpal segments, the femur and tibiotarsus. Latreille's description is ambiguous on this point, as he states only that the two segments are strongly elongated.

Geoffroy's (1762) figure depicts "*La pince rouge*" as having a four-segmented palpus: trochanter, femur (basifemur and telofemur), genu, and tibiotarsus. The palpal apices are shown to be expanded distally, obliquely truncate, with two subequal end setae slightly longer than the femora, and the tibiotarsi approximately two thirds the length of the femora. "*La pince rouge*" clearly belongs to the genus *Bdella, sensu* Thor (1931a). When Latreille's description is compared with Geoffroy's figure, the description loses its ambiguity and the following synonymy becomes probable: *Acarus longicornis* L., 1758 = "*La pince rouge*" Geoffroy, 1762 = *Bdella longicornis* Latr., 1795 = *Bdella longicornis, sensu* Thor, 1931a.

Vitzthum (1931) interprets Latreille's description as meaning that the longer segments, the femur and the tibiotarsus, are approximately equal in length, thereby placing *Bdella* in the Odontoscirinae, *sensu* Thor (1931a) and Grandjean (1938). To the present author, Vitzthum's interpretation seems incorrect.

Hermann (1804) erected the genus *Scirus* for ". . . les Mites dont Linné et Geoffroy n'ont connu qu'une seule espèce, appalée par le premier *acarus longicornis*. . . ." His type species, *Scirus vulgaris,* is figured as having short, widened palpal tibiotarsi and is considered to be synonymous with *Acarus longicornis* L. (Thor, 1931a; Oudemans, 1937; *non* Vitzthum, 1931). The genus *Scirus, sensu* Hermann must therefore be synonymized with *Bdella, sensu* Thor.

A second species described by Hermann (1804), *Scirus longirostris,* is figured as having the terminal palpal segment cylindrical, approximately as long as the femur and the end hairs approximately the length of the tibiotarsus, a condition commonly found only in the Odonotscirinae. *S. longirostris* has been regarded as the type species for *Scirus, sensu* Thor (*non* Hermann, 1804), but as *Scirus* and *Bdella* are isogenotypic, the name *Scirus* is invalid. Oudemans (1937) recognized this inconsistency and proposed the name *Bdellodes* to replace *Scirus, sensu* Thor.

Characters and Descriptive Methods

To simplify the species descriptions, characters are presented in an abbreviated form. Important morphological features used in the descriptions are discussed fully in the morphology section. For species being redescribed, the intraspecific variations in measurements and counts (*e. g.*, setae) observed in the study specimens are expressed as ranges immediately following the character being described. For new species, variations are noted in the remarks section following each description.

A phase contrast microscope was used throughout this study. A grid in the eyepiece was used to draw the figures to scale.

Following the same sequence as will be found in the formal descriptions that follow, the characters and descriptive methods are explained in the following section.

Color in life, which has been extensively used as a taxonomic character by earlier workers, is apparently dependent on body contents in most species. Although no experiments were undertaken to demonstrate that bdellids change color on different diets, the author noted that *Cyta coerulipes,* the only species with a purple integument, in life varied from purple to brown with yellow blotches. A few species have black, subcutaneous spots beneath the lateral eyes, but these disappear after the specimens have been treated with lacto-phenol clearing solution.

Length, including gnathosoma is a highly variable measurement. Nongravid females and males are approximately the same size, but the hysterosoma of gravid females becomes greatly distended, thereby creating an erroneous impression of the species size.

Palpus. Illustrations are of the median aspect of the left palpus. Measurements of the palpal segments were taken from the dorsal surfaces and are given in the following order: trochanter (I), basifemur (II), telofemur (III), genu (IV), tibiotarsus (V), dorsal end seta (*des*), and ventral end seta (*ves*). Variations in the number of setae are indicated in the remarks section following each description.

Chelicera. The shape of the chelicera may be normal, which means that it is approximately three to five times as wide at the base as at the thinnest portion (fig. 12). Inflated chelicera indicates that the width at the base is more than seven times greater than at the thinnest portion (fig. 13), and elongated chelicera has sides that are approximately parallel (figs. 32-35). The chelae in the majority of the genera are small and the ventral, movable digit sickle-shaped (fig. 7*b*). Smooth chelae means that the blades lack teeth on the

inner surfaces. In the Odontoscirinae, the inner surface of the movable digit may be flattened subapically. This flattened surface extends proximally to the level of the tip of the fixed digit (fig. 8). The length of a chelicera is measured from the base to the apex of the longest digit.

Hypostome. As viewed from the ventral aspect (fig. 2), the gnathosoma consists of a rectangular base carrying the palpal articulations at the anterolateral angles, and an anteriorly projecting hypostome. The latter structure consists of a long, tapering buccal cone, and two small, distally fringed lateral lips. The gnathosomal base is always transversely striated, but the buccal cone may be striated or nonstriated. In the latter case, the integument may appear to be granulated. In adults, there are two, six or seven pairs of large setae in two longitudinal series on the ventrolateral surfaces of the hypostome that extend from the anterior margin of the gnathosomal base to the proximity of the lateral lips. These setae, the ventral hypostomals, are indicated as the *vh* series and are numbered consecutively from the base, thus, the proximal pair of setae is *vh 1*. The positions of the ventral hypostomal setae may be important in future taxonomy, therefore, relative positions are indicated in the descriptions. Two dorsal hypostomal setae may be present beneath the cheliceral bases. If present, these setae are inserted approximately above the palpal articulations. The lengths of the dorsal hypostomal setae are compared to the lengths of the setae comprising the ventral series.

Propodosoma. The integumental striae of this area, although not always specific, appear in different structural types and patterns. The breaks along the crests of these integumental ridges vary in frequency and regularity and on this basis have been divided into three categories. Sparsely broken striae (fig. 136) indicates that the breaks occur at long and irregular intervals. Coarsely broken striae (fig. 151) divide at regular intervals with the lengths of the uninterrupted crest approximately six to eight times longer than the breaks. Finely broken striae (fig. 133) indicates that the undivided lengths of the crests are only two to three times longer than the breaks. Although it might be expected that many intergrades would occur between these arbitrary groups, this is not the case. Intergrades occur in only one or two instances, and these are between the coarsely and finely broken striation groups.

The lateral propodosomal setae (figs. 1 *d*, 133 *c*) are inserted lateral to a line connecting the dorsal sensilla on each side. The

presence or absence of this pair is considered to be of generic significance (except *Thoribdella*). The median propodosomals (fig. 1 *f*, 133 *f*) are always present and are inserted in the interval between the posterior sensilla.

On each side of the body, the eyes may be approximate or distant and the distance between the eyes is compared to the diameter of either the anterior or posterior eyes. In *Bdella* and *Spinibdella*, the direction of the striae in the interocular interval may be longitudinal, thus connecting the eyes, or transverse.

Dorsal hysterosoma. The interval between an internal humeral and an internal dorsal seta (fig. 1 *h, j*) is considered to be the first interspace and is used as a comparison with the length of the humeral seta.

Anal region. The border striae are those striae which parallel the entire length of the anal cleft or those which bend sharply laterad near the center of the cleft. Setae inserted in the region of the parallel striations are the anal setae (fig. 2 *j*). A pair of postanal setae (fig. 1 *o*) flanks the dorsal termination of the cleft. Other setae surrounding the anal cleft are considered to be the paranal setae.

Genital region. Two membraneous plates or flaps cover the genital vestibule, each of which has a regular or irregular row of genital setae (figs. 2 *i*, 178 *a*). Setae surrounding these plates are the paragenital setae (figs. 2 *g*, 178 *b*), and although a few of these setae occur between the coxae, no satisfactory division could be made to separate these setae into groups of paragenitals and intercoxals. In the Cytinae, an unpaired median seta occurs immediately anterior to the genital flaps (fig. 178 *c*).

Setae inserted on the ovipositor are indicated by position. Those surrounding the apex are termed the subapical setae, and those slightly distal to the midlength of the ovipositor are termed the postmedial setae.

The large, heavily sclerotized amphioid sclerites of the male each bears a peripheral row of setae of various lengths and shapes (figs. 169-177). In *Spinibdella* and *Cyta*, the differences in the peripheral setae are believed to be specific. In other genera, setal differences could not be evaluated. However, in this latter group of genera, the setae are divided into distinct groups and are recorded as such in the descriptions. For example, "amphioid sclerites with 4, 1, 3, 2" would indicate that in the peripheral row of

setae, a group of four setae are anterior, then a single seta, then a group of three setae, and finally near the caudal termination of the sclerite, two setae.

Legs. Small or minute lateral rays on the claws refers to a row of tiny spines, each of which is approximately the width of the claw. Large lateral rays are similar in structure to the above, but are less numerous and more than three times the width of the claw (fig. 70). Measurements of the legs are given in microns for the tibia and tarsus (excluding the pretarsus) of legs I and II. The chaetotaxy is given for each segment, starting with coxa I. If only one type of seta occurs on more than one segment of a series (*e. g.*, coxae), this is indicated in an abbreviated form. For example, "coxae I-IV, 5, 4, 6, 4 tactile setae" means that only tactile setae occur on the coxae and coxa I has five tactile setae, coxa II has four tactile setae, etc. When segments have more than one type of seta, each segment is given individually. The different types of setae found on the legs are illustrated in figs. 179-197.

Description of the Family Bdellidae

Bdellei Dugès, 1834, Ann. Sci. Nat., ser. 2, vol. 1, Zool., p. 21.

Medium to large mites (approximately 0.5 to 3.5 mm.) with finely striated integument (*Trachymolgus* armored); subcutaneous shields may be present on the propodosoma; conelike gnathosoma formed by elongated, chelate chelicerae bearing one or more setae, and a ventral hypostome bearing two, six, or seven pairs of conspicuous ventrolateral setae and two pairs of minute setae inserted on the lateral lips; geniculate palpi five-segmented, trochanter and genu short, femur divided distally into a short telofemur and a long basifemur; tibiotarsus of various lengths and bears apically two long setae (one in *Monotrichobdella*); tracheal openings near cheliceral bases; idiosoma divided dorsally into propodosoma and hysterosoma; four dorsal sensilla inserted in pseudostigmatic organs; two, four, or five eyes present; legs eight-segmented (including short pretarsus) with two claws and a padlike, rayed puvillus; maximally five pairs of trichoboths; well developed genital tracheae may be present; three pairs of genital suckers; anal cleft terminal; sexes similar. The subfamilies erected by Grandjean (1938) are incorporated in the following generic key.

Key to the Genera of the Family Bdellidae

1. Venter of hypostome with six or seven pairs of strong setae and two pairs of small adornal setae; without well developed genital tracheae 2
   Venter of hypostome with two pairs of strong setae and two pairs of small adornal setae; with well developed genital tracheae 7
2. Trichoboth absent on tibia II ..... (Bdellinae) *Bdella* p. 372
   Trichoboth present on tibia II ..... (Odontoscirinae) 3
3. Each chelicera with more than two setae, usually eight to twenty ..... *Neomolgus* p. 389
   Each chelicera with one or two setae 4
4. Posterior pseudostigmata goblet-shaped; posterior sensilla reduced in size, usually much shorter than median propodosomal setae ..... *Thoribdella* p. 394
   Posterior pseudostigmata simple; posterior sensilla not reduced in size and longer than median propodosomal setae 5
5. Lateral propodosomal setae present ..... *Octobdellodes* p. 407
   Lateral propodosomal setae absent 6
6. Chela with inner surface of movable digit straight and bearing one or more small teeth; cheliceral bases inflated; lateral lips of hypostome prominent ..... *Odontoscirus* p. 386
   Chela with movable digit sickle-shaped and bearing one or no teeth; cheliceral bases not inflated; lateral lips of hypostome as in other genera ..... *Bdellodes* p. 412
7. Cheliceral bases normal to inflated, chela with movable digit sickle-shaped; unpaired median seta immediately anterior of genital opening ..... (Cytinae) 8
   Chelicerae elongated; chelae with digits reduced, needlelike; unpaired median seta, if present, between coxae IV ..... (Spinibdellinae) 9
8. Integument soft, striated; chelae massive; unpaired median eye between anterior sensilla ..... *Cyta* p. 416
   Integument armored, pitted; chelae not massive; without unpaired median eye ..... *Trachymolgus* p. 423
9. Lateral propodosomal setae present; palpal tibiotarsus expanded distally (truncated) ..... *Spinibdella* p. 424
   Lateral propodosomal setae absent; palpal tibiotarsus cylindrical, elongated 10
10. Palpal tibiotarsus with two long apiacl setae ..... *Biscirus* p. 435
    Palpal tibiotarsus with one long apical seta ..... *Monotrichobdella* p. 438

Bdellinae Grandjean, 1938

The Bdellinae, containing only the genus *Bdella,* is characterized by having six pairs of ventral hypostomal setae, four pairs of trichoboths (*Bdella mexicana* has three pairs), and undeveloped genital tracheae. No exceptions were found in the material examined; however, Vitzthum (1943) reports an undescribed species of *Bdella* which has one pair of weakly developed genital pouches.

Genus *Bdella* Latreille

Bdella Latreille, 1795, Magasin encyclopédique, ou Journal des Lettres et des Arts, Paris, vol. 4, p. 18. (Type: *Acarus longicornis* Linnaeus, 1758, by subsequent identification, Latreille, 1796, Précis des Caractères génériques des Insectes, disposés dans un Ordre naturel, par [Pierre André] Latreille, Paris, p. 180).

Chelifer Geoffroy, 1762, Histoire abrégée des Insectes, qui se trouvent aux Environs de Paris; dans laquelle ces Animaux sont rangés suivant un Ordre méthodique, par Etienne Louis Geoffroy, vol. 2, p. 617. (Type: *Chelifer totus ruber, antennis extremo bisetis: Pince rouge* Geoffroy, 1762 [= *Acarus longicornis* L.] [monobasic].)

Scirus (Ciron) Hermann, 1804, Mémoire aptérologique. Ouvrage couronné en 1790 par la Société d'Histoire naturelle de Paris, Publié par Fréderic-Louis Hammer, Strasbourg, p. 60. (Type: *Scirus vulgaris* Hermann, 1804 [= *Acarus longicornis* L.] [first included species].)

Bdellidium Oudemans, 1929, Ent. Ber. Nederl. Ver., vol. 7, p. 449 (new synonym). (Type: *Scirus vulgaris* Hermann, 1804 [= *Acarus longicornis* L.] [by original designation].)

Caenobdella Oudemans, 1937, Kritisch Historisch Overzicht der Acarologie, Leiden, vol. 3, part C, p. 1227 (new synonym). (Type: *Bdella crassipes* C. L. Koch, 1839 [by original designation].)

In addition to the subfamily characters, the palpal tibiotarsus is truncate and considerably shorter than the palpal basifemur; the subequal end setae are as long as or longer than the palpal femur. Normal to inflated chelicerae bear two setae inserted on the proximal three fourths of their lengths, and the small chelae have sickle-shaped movable digits, each of which may have one small tooth. The dorsal propodosoma with four pairs of eyes lateral to the unmodified posterior pseudostigmatic organs. The podocephalic canal is an external groove (Grandjean, 1938).

The genus *Caenobdella* Oudemans is based on the inadequate description of *Bdella crassipes* Koch, 1839. Koch's illustration shows five trichoboths on the right side of the animal and four trichoboths on the left side. The trichoboths of legs III, one pair inserted on tibiae III, one on the right tarsus III, are the distinguishing features of *Caenobdella*. In this author's opinion, these discrepancies represent mistakes made by Koch, and therefore, should not be considered to represent significant structures.

KEY TO THE SPECIES OF BDELLA

1. Distance between anterior sensilla bases less than between posterior sensilla; striae of propodosomal shield, if longitudinal, not directed between anterior sensilla 2
   Distance between anterior sensilla bases greater than between posterior sensilla; striae of propodosomal shield longitudinal, directed between anterior and posterior sensilla 5
2. Propodosomal shield with all striae convex caudally 3
   Propodosomal shield with anterior striae convex caudally, posterior striae longitudinal, directed between posterior sensilla 4

3. Shield with finely broken striae; palpus with thirteen or more setae on basifemur, seven setae (including end setae) on tibiotarsus *longicornis* p. 373
   Shield with sparsely broken striae; palpus with eight to eleven setae on basifemur, six setae (including end setae) on tibiotarsus *muscorum* p. 375
4. Telofemur, genu, and tibia of leg I approximately equal in length, genu I without duplex seta *tropica* p. 378
   Tibia I two times longer than genu I or telofemur I; genu I with duplex seta *longistriata* p. 380
5. Tarsus IV with trichoboth; dorsal hysterosomal setae branched distally; transverse striae between eyes *distincta* p. 381
   Tarsus IV without trichoboth; dorsal hysterosomal setae nude or plumose; longitudinal striae between eyes *mexicana* p. 383

Bdella longicornis Linnaeus

(Figs. 7, 12, 37, 69-72, 133-135, 169)

Acarus longicornis Linnaeus 1758, Systema Naturae, 10th ed., p. 618.
"Chelifer totus ruber, antennis extremo bisetis; Pince rouge" Geoffroy, 1762, Hist. Abr. Ins., vol. 2, pp. 618-619.
Scirus vulgaris Hermann, 1804, Méin, Apt., p. 61.
Bdella anguinesetosa Ewing, 1910, Univ. Stud., Univ. Illinois, vol. 3, no. 6, p. 72 (new synonym).
Bdella tessellata Ewing, 1913, Bull. Amer. Mus. Nat. Hist., vol. 32, p. 112 (new synonym).

This widespread species is closely related to *Bdella muscorum* Ewing, 1909, and to *Bdella iconica* Berlese, 1923. *B. longicornis* can be distinguished from *B. muscorum* by having seven setae (including two apical setae) on the palpal tibiotarsus rather than six, and in having the interlacing secondary apodemes of the dorsal propodosomal shield lateral to the bell-shaped primary apodemes (fig. 133) rather than mesad (fig. 136). The palpal tibiotarsus of *B. iconica* is identical to that of *longicornis*, but the striae of the propodosomal shield are convex caudad in *longicornis* rather than being directed between the median propodosomal setae.

Female: Color in life, deep pink to red, with irregular brown to dark blue blotches. Body ovoid, weakly constricted; length, including gnathosoma, 1160 μ (850-1475 μ). *Gnathosoma:* Length, 320 μ (209-396 μ); palpus (fig. 37) with tibiotarsus extending beyond hypostome; measurements: I, 15 μ (11-16 μ); II plus III, 327 μ (142-371 μ); IV, 30 μ (20-38 μ); V, 95 μ (54-115 μ); *des*, 243 μ (187-464 μ); *ves*, 195 μ (141-367 μ). Chelicera (figs. 7, 12) normal, finely striated, 300 μ (193-423 μ) in length; movable digit smooth, equal in length to fixed digit; setae as in fig. 12. Hypostome striated; *vh 1* and *vh 2* form transverse row between palpal articulations; dorsal hypostomals wanting. *Dorsal propodosoma*

(figs. 133-135): Striae finely to coarsely broken; lateral propodosomals nude, 57 μ (43-100 μ); median propodosomals nude, 67 μ (57-128 μ) in length; eyes separated by diameter of anterior pair; distance between anterior sensilla, 74 μ (56-143 μ); large pore anterolaterad to lateral propodosomal seta. *Dorsal hysterosoma:* Setae nude; internal humeral, 70 μ (57-116 μ) in length, approximately the length of first interspace; external humeral, 99 μ (70-184 μ) in length; sacrals and clunals in gently curving rows. *Anal region:* Border striae parallel; one pair of anals; 5 pairs of paranals; postanals anterior to cleft, longer than external clunals. *Genital region:* Each genital plate with 7 (6-8) equal genital setae in irregular linear arrangement; 9 (10) pairs of paragenitals, anterior pair not between coxae IV; genital discs small, equidistant, in posterior two thirds of vestibule; ovipositor with 10 subapical and 10 postmedial setae. *Legs* (figs. 69-72): Claws with 4-5 lateral rays, 1 row of minute rays each; measurements: tibia I, 114 μ (65-180 μ); tarsus I, 146 μ (100-201 μ); tibia II, 87 μ (52-143 μ); tarsus II, 125 μ (83-180 μ). Chaetotaxy: coxae I-IV, 6 (5), 6 (5), 5, 3 (4) tactile setae; trochanters I-IV, 1, 1, 2, 2 tactile setae; basifemora I-IV, 13 (11-17), 11 (11-15), 11 (11-14), 6 (7) tactile setae; telofemora I-IV, 11 (11-13), 11 (11-13), 11 (12), 9 (9-11) tactile setae; genu I, 9 (8) tactile setae, 1 duplex seta, 3 (3-6) attenuate sensory setae; genu II, 9 tactiles, 1 duplex, 1 (2) attenuate sensory setae; genu III, 9 tactiles, 1 duplex, 1 attenuate sensory seta; genu IV, 10 (11) tactiles, 1 attenuate sensory seta; tibia I, 16 tactiles, 5 (5-9) attenuate sensory setae, 1 attenuate peg, trichoboth; tibia II, 15 (13-15) tactile setae, 2 attenuate sensory setae, one blunt sensory seta; tibia III, 16 (17) tactile setae, one attenuate sensory seta; tibia IV, 15 tactiles, trichoboth; tarsus I, 14 (16) ventrals, distal pairs plumose, 10 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 attenuate peg, dorsoterminals minutely plumose; tarsus II, as in tarsus I, except lacking 2 attenuate sensory setae and 1 lateral seta; tarsus III, 14 ventrals, distal pairs plumose, 9 laterals, trichoboth, dorsoterminals as in leg I; tarsus IV, 14 ventrals, 7 (8) laterals, trichoboth, 1 attenuate sensory seta distal to trichoboth, *dt 1* reduced to one seta, *dt 2, 3* minutely plumose.

Male: Identical to female; amphioid sclerites (fig. 169) with 7, 1, 2 setae each.

Type: Europe.

Location of type: Unknown.

Remarks: Two of H. E. Ewing's types available for study from the U. S. National Museum were: *Bdella anguinisetosa* (tritonymph), June 5, 1905, H. E. Ewing; and *Bdella tessellata* (female), Portage, Wisconsin, September 2, 1909, H. E. Ewing, under an old piece of bark.

In addition, approximately 250 specimens were examined, which included material from: Barro Colorado Island, Panama Canal Zone, Costa Rica, Cuba, Mexico (Oaxaca, Distrito Federal, México, San Luis Potosí), United States (California, Texas, Utah, Arkansas, Kansas, Illinois, Tennessee, Florida, Missouri, Michigan, New Hampshire, Vermont), and Nova Scotia.

The numbers of setae on the palpal segments are: basifemur, 14 (13-15); telofemur, 1; genu, 4; tibiotarsus, 4 tactile setae, 1 attenuate sensory seta, and two long apical setae. The length of the solid tactile seta on the dorsal surface of the palpal tibiotarsus is slightly longer, to more than twice the length of the attenuate sensory seta.

The variation in total length is considerable, but more striking is the variation in cuticular deposition shown by the internal apodemes of the dorsal propodosoma (figs. 133-135). Geographical variation could not be demonstrated in this species. Within one area, individual mites could be found which exhibited all combinations of the variable characters.

The illustrations were prepared from females from: West slope of Cortez Pass, Mt. Popocatepetl, México, Mexico, August 11, 1954, W. T. Atyeo, moss sample off tree (Berlese funnel extraction), alt. 11,500 ft.

Bdella muscorum Ewing

(Figs. 39, 73, 74, 136-139)

Bdella muscorum Ewing, 1909, Canadian Ent., vol. 41, no. 4, pp. 124-125.
Bdella lata Ewing, 1910 (*non* Koch & Berendt, 1854, fossil *Bdella?*), Univ. Stud., Univ. Illinois, vol. 3, no. 6, p. 69.
Bdella subnigra Ewing, 1910, Univ. Stud., Univ. Illinois, vol. 3, no. 6, p. 73 (new synonym).
Bdella muscorum var. *minnesotensis* Ewing, 1913, Bull. Amer. Mus. Nat. Hist., vol. 32, p. 113 (new synonym).
Bdella recens Ewing, 1937 (*pro, Bdella lata* Ewing, *nom praeocc.*), Univ. Toronto Stud., Geological Ser., no. 40, p. 57 (new synonym).

This species is closely related to *Bdella longicornis*, and due to many superficial similarities, these two species may be easily confused. In addition to differences in the chaetotaxy of the legs, *B. muscorum* can be easily differentiated by the palpal chaetotaxy, the basifemur having eight to eleven setae and the tibiotarsus having a total of six setae. The palpus of *B. longicornis* has thirteen or more setae on the basifemur and seven setae on the tibiotarsus.

Female: Color unknown. Body ovoid, weakly constricted; length, including gnathosoma, 825 μ (710-1170 μ) *Gnathosoma:* Length, 224 μ (206-331 μ); palpus (fig. 39) with tibiotarsus extending beyond hypostome; measurements: I, 15 μ (13-18 μ); II plus III, 135 μ (133-198 μ); IV, 26 μ (20-35 μ); V, 60 μ (55-99 μ); *des,* 175 μ (110-220 μ); *ves,* 129 μ (129-182 μ). Chelicera normal, finely striated, 215 μ (207-300 μ) in length; chela smooth, fixed digit blunt, slightly shorter than movable digit; distal seta extending to base of chela, proximal seta extending to insertion of distal seta; setae inserted as in fig. 12. Gnathosoma striated; *vh 1-2* in strongly curved transverse row between palpal articulations, *vh 2, 3, 5, 6* progressively more widely separated and form 2 longitudinal series, *vh 1, 4* laterad of series; dorsal hypostomal setae wanting. *Dorsal propodosoma* (figs. 136-139): Striae sparsely broken; lateral propodosomals nude, 57 μ (47-78 μ) in length; median propodosomals nude, 74 μ (71-99 μ) in length; eyes separated by distance equal to diameter of anterior pair, interval between eyes with longitudinal striae; distance between anterior sensilla, 70 μ (61-97 μ). *Dorsal hysterosoma:* Setae nude; length of internal humeral, 79 μ (79-98 μ), approximately three fourths of first interspace; external humeral, 105 μ (92-124 μ) in length; sacrals and clunals in gently curving transverse rows. *Anal region:* Border striae parallel, 2 pairs of anal setae, 5 (4) pairs of paranals anterior to termination of cleft, longer than external clunals. *Genital region:* Each genital plate with 8 (9) small equal genital setae in linear arrangement; 10 pairs of paragenitals, anterior pair not between coxae IV; genital discs small, approximately equidistant, in posterior three fourths of vestibule; ovipositor with 10 subapical and 8 postmedial setae. *Legs* (figs. 73, 74): Claws with 4-6 lateral rays, one row of minute rays each; measurements: tibia I, 74 μ (64-100 μ); tarsus I, 90 μ (85-124 μ); tibia II, 53 μ (45-82 μ); tarsus II, 75 μ (71-108 μ). Chaetotaxy: coxae I-IV, 5 (6), 6 (5), 5 (7), 4 (3) tactile setae; trochanters I-IV, 1, 1 (2), 2, 2 tactile setae; basifemora I-IV, 10 (8-14), 8 (7-10), 9 (8), 5 (6) tactile setae; telofemora I-IV, 7 (8-11), 7 (6-10), 7 (8-9), 8 (7) tactile setae; genu I, 6 (6-8) tactile setae, 1 (2) attenuate sensory seta(e), 1 duplex seta; genu II, 6 (6-8) tactiles, 1 duplex; genu III, 6 (6-8) tactiles, 1 duplex; genu IV, 8 tactiles, 1 attenuate sensory seta; tibia I, 14 (13) tactiles, 4 attenuate sensory setae, 1 peg, trichoboth; tibia II, 11 tactiles, 2 (1) attenuate sensory seta(e), 1 blunt sensory seta; tibia III, 12 (10-14) tactiles, 1 attenuate sensory seta; tibia IV, 13 (11-12) tactile setae, trichoboth; tarsus I, 13 (14)

plumose ventrals arranged in 2 rows, 8 lateral and 2 dorsal tactiles, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* hollow, nude, *dt 2, 3,* solid, plumose; tarsus II, 10 (11-12) plumose ventrals, 6 lateral and 2 dorsal tactiles, 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, 12 (11) ventrals, 7 (6-8) laterals, trichoboth, *dt 1* solid, nude, *dt 2, 3,* solid, plumose; tarsus IV, 12 (11) ventrals, 6 laterals, 1 attenuate sensory seta, trichoboth, *dt 1* reduced to one, solid, nude seta, *dt 2, 3,* solid, plumose.

Male: Identical to female; amphioid sclerites with 6, 1, 2 setae each.

Type: Female, Muncie, Illinois, June 16, 1908, H. E. Ewing, in moss.

Location of type: The United States National Museum.

Remarks: Three additional type specimens were examined and found to be conspecific with *B. muscorum;* these were: *Bdella recens* Ewing, 1937 (*pro, B. lata,* Ewing, *nom praeocc.*), sex unknown (incomplete specimen), Mahomet, Illinois, April 17, 1908, H. E. Ewing; *B. subnigra* Ewing, 1910, female, Mahomet, Illinois, April 17, 1908, H. E. Ewing, in moss; *B. muscorum* var. *minnesotensis* Ewing, 1913, female, Minnesota, April 24, 1900. Additional material studied included specimens from: The United States (California, Colorado, New Mexico, Kansas, Arkansas, Tennessee, Michigan, Illinois, Maryland), Alaska (Point Barrow, Chandler Lake Region, Umiat, District of Mackenzie), Germany (Ost-Holstein), Czechoslovakia, and Iceland.

In the Old World specimens, the mesal margins of the dorsal propodosomal apodemes are more highly developed than the lateral margins, whereas in the New World material, the reverse is true (fig. 136). However, in either condition, there is little variation in the characteristic shape of the apodemes.

As indicated in the description, the chaetotaxy of the legs is relatively constant. The chaetotaxy of the palpus is as follows: basifemur, eight to eleven tactile setae, usually ten; telofemur, one seta; genu, four setae; tibiotarsus, three tactile setae, one attenuate sensory seta, and two long apical setae. The dorsal sensory seta and the dorsal tactile seta fluctuate considerably in actual and relative lengths. The tactile seta may be slightly longer, or as in the Icelandic specimens, almost twice the length of the sensory seta. Drawings of a female from Douglas Lake, Cheboygan Co., Michigan, June 24, 1957, R. E. Beer, moss (Berlese funnel extraction).

Bdella tropica, sp. nov.

(Figs. 40, 77, 78, 140)

This species is closely related to *Bdella distincta,* but has long, nude, dorsal hysterosomal setae rather than short, distally branched setae, and has a different propodosomal striation pattern (figs. 140, 141). Although this new species does not appear to be closely related to *Bdella grandjeani* Thor (1931b) from Tanganyika, the propodosomal striae form similar patterns in both species.

Female: Color in life unknown. Body narrowly ovoid, weakly constricted; length, including gnathosoma, 810 μ. *Gnathosoma:* Length, 211 μ; palpus (fig. 40) short, only apex of tibiotarsus extending beyond hypostome; measurements: I, 12 μ; II plus III, 121 μ; IV, 24 μ; V, 45 μ; *des,* 175 μ; *ves,* 153 μ. Chelicera normal, finely striated, 204 μ in length; chela smooth, fixed digit attenuate, extending slightly beyond movable digit; distal seta extending to base of chela, slightly longer than proximal seta; setae inserted as in *Bdella longicornis* (fig. 12). Gnathosoma faintly striated; ventral setae in two longitudinal series, *vh 1* between palpal articulations, distance between *vh 1* and *vh 2* equal to distance between *vh 5* and *vh 6,* distance between *vh 2* and *vh 3* equal to one half distance between *vh 3* and *vh 4* or *vh 4* and *vh 5;* dorsal hypostomal setae delicate, same length as proximal pair of ventral setae. *Dorsal propodosoma* (fig. 140): Striae finely broken; lateral propodosomals nude, 56 μ in length; median propodosomals nude, 125 μ in length; eyes approximate, separated by 3 transverse striae; distance between anterior sensilla, 92 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 75 μ, approximately five sixths of first interspace; external humeral, 238 μ in length; sacrals and clunals in gently curving transverse rows. *Genital region:* Each genital plate with 8 small, equal, genital setae in linear arrangement, 9 pairs of paragenitals, anterior pair between coxae IV; genital discs small, anterior pair near center of vestibule, posterior two pairs approximate, near caudal end; ovipositor with 10 subapical and 8 postmedial setae. *Anal region:* Border striae bending laterad; one pair of anal setae anterior, one pair posterior to laterally-directed striae; one pair of paranals; postanals flanking termination of cleft, shorter than clunal setae. *Legs* (figs. 77, 78): Claws with 2-3 basal, lateral rays and one row of minute rays each; measurements: tibia I, 51 μ; tarsus I, 91 μ; tibia II, 38 μ; tarsus II, 79 μ. Chaetotaxy: coxae I-IV, 6, 5, 6, 4 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 8, 9, 7, 4 tactile setae; telofemora I-IV, 5 tactile setae

each; genu I, 5 tactile setae, 2 attenuate sensory setae, 1 duplex seta; genua II-III, 6 tactile setae and 1 duplex seta each; genu IV, 5 tactile setae, 1 duplex seta; tibia I, 7 tactile setae, 3 attenuate sensory setae, 1 attenuate peg, trichoboth; tibia II, 7 tactile setae, 2 attenuate sensory setae, 1 blunt sensory seta; tibia III, 8 tactile setae, 1 attenuate sensory seta; tibia IV, 10 tactile setae, trichoboth; tarsus I, 9 plumose ventral setae arranged in 2 rows, 7 lateral and 2 dorsal tactile setae, 2 blunt and 2 attenuate sensory setae, 1 hollow, blunt peg, *dt 1* hollow, pilose, *dt 2, 3* solid, plumose; tarsus II, 8 plumose ventrals, 4-5 lateral and 2 dorsal tactile setae, 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, 10 plumose ventrals, 6 laterals, trichoboth, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus IV, 10 plumose ventrals, 5 laterals, trichoboth, 1 attenuate sensory seta distal to trichoboth, dorsoterminals as in tarsus III.

Male: Unknown.

Holotype: Female, Barro Colorado Island, Canal Zone, Panama, July 27, 1956, Carl W. Rettenmeyer, bark moss (Berlese funnel extraction).

Paratypes: Twenty-three females from Barro Colorado Island, Canal Zone, Panama, collected by Carl W. Rettenmeyer by Berlese funnel extraction with the following data: nine females, same data as the holotype; eight females collected July 24, 1956, rotten stump; three collected July 10, 1956, grass roots from clearing; two collected August 1, 1956, soil and leaves; one collected March 26, 1956, rotten stump; one collected July 28, 1956, dirt and leaves. Also, four females, Barro Colorado Island, May 12, 1956, C. W. and M. E. Rettenmeyer, colony E:148, *Eciton burchelli*, refuse deposit.

Location of types: The holotype and twenty-one paratypes are deposited in the Snow Entomological Museum; two paratypes are deposited at each of the following institutions: the United States National Museum, the British Museum (Natural History), and the South Australian Museum.

Remarks: Little variation is apparent in this species. The length, including the gnathosoma, varies from 780 μ to 910 μ, and other measurements vary proportionately, *e. g.*, the palpal femur, 112 μ to 124 μ. The number of tacitle setae on the leg segments vary from one more, to one less, than the number indicated in the description of the holotype. This species, collected only on Barro Colorado Island, may be restricted to the tropical regions, hence the name *tropica*. Drawings of the holotype.

Bdella longistriata, sp. nov.

(Figs. 38, 75, 76, 151, 170)

This species may be related to *Bdella tropica,* sp. nov., but can be easily distinguished by the lack of long setae on the dorsal surface of the palpal tibiotarsus.

Female: Color in life unknown. Body ovoid, weakly constricted; length, including gnathosoma, 902 μ. *Gnathosoma:* Length, 252 μ; palpus (fig. 38) with tibiotarsus extending beyond hypostome; measurements: I, 17 μ; II plus III, 190 μ; IV, 21 μ; V, 48 μ; *des,* 255 μ; *ves,* 204 μ. Chelicera normal, finely striated, 274 μ in length; chela smooth, fixed digit attenuate, slightly shorter than movable digit; distal seta extending three fourths of distance to base of chela, proximal seta extending one half the distance to distal seta; setae inserted as in fig. 12. Gnathosoma striated; *vh 1-6* in two longitudinal series, *vh 1* between palpal articulations, *vh 1-5* approximately equidistant, *vh 6* midway between *vh 5* and apex; dorsal hypostomal setae wanting. *Dorsal propodosoma* (fig. 151): Striae sparsely broken; lateral propodosomals nude, 60 μ in length; median propodosomals thickened, nude, 146 μ in length; eyes separated by distance equal to diameter of anterior pair, interval between eyes transversely striated; distance between anterior sensilla, 92 μ. *Dorsal hysterosoma:* Setae thickened, nude; length of internal humeral, 98 μ, approximately one fourth longer than first interspace; external humeral, 153 μ in length; sacrals and clunals in gently curving transverse rows. *Anal region:* Border striae parallel; anal setae wanting; 2 pairs of paranals; postanals flanking termination of cleft, equal in length to external clunals. *Genital region:* Each genital plate with eleven equal setae in linear arrangement; 9 pairs of paragenitals, anterior pair between coxae IV; genital discs small, widely separated, one pair at each end of vestibule, one pair near middle; ovipositor with 10 subapical, 8 postmedial setae. *Legs* (figs. 75, 76): Claws with one row of small, lateral rays each; measurements: tibia I, 81 μ; tarsus I, 108 μ; tibia II, 60 μ; tarsus II, 102 μ. Chaetotaxy: coxae I-IV, 5, 4, 6, 5 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 11, 12, 9, 4 tactile setae; telofemora I-IV, 9, 9, 9, 6 tactile setae; genu I, 7 tactile setae, 1 duplex seta, 1 attenuate sensory seta; genua II-IV, 8 tactile setae, 1 duplex seta each; tibia I, 12 tactile setae, 2 attenuate sensory setae, 1 attenuate peg, trichoboth; tibia II, 12 tactile setae, 1 attenuate and 1 blunt sensory seta; tibia III, 9 tactile setae, 1 attenuate sensory seta; tibia IV, 13 tactile setae, trichoboth; tarsus I, 11 plumose ventrals in 2 rows, 10 lateral

and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 attenuate peg, dorsoterminals solid, minutely pilose; tarsus II, 10 plumose ventrals, 7 lateral and 2 dorsal tactile setae, 2 blunt sensory setae, 1 attenuate peg, dorsoterminals as in tarsus I; tarsus III, 12 plumose ventrals, 8 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 12 plumose ventrals, 6 laterals, trichoboth, 1 attenuate sensory seta proximal to trichoboth, dorsoterminals as in tarsus I.

Male: Identical to female except in total length and genital region; length, including gnathosoma, 880 μ. *Genital region:* Thirteen equal setae in linear arrangement on each genital plate; 10 paragenitals, anterior pair between coxae IV; genital discs small, widely separated; genital aperture large, about one half the length of the hysterosoma; amphioid sclerites (fig. 170) extending from between coxae IV to near the ventral termination of anal cleft.

Holotype: Female, 8 miles north of Llera, Tamaulipas, Mexico, July 19, 1954, W. T. Atyeo, beating pineapple epiphyte on mesquite.

Allotype: Male, Cuidad del Maiz, San Luis Potosí, Mexico; at Laredo, Texas, July 10, 1945, T. P. Chapman, on orchid plants.

Paratypes: One male, one female, 8 miles west of Antiguo Morelos, Tamaulipas, Mexico, July 21, 1954, W. T. Atyeo, under log; one female, Mante, Tamaulipas, Mexico; at Laredo, Texas, March 28, 1945, C. D. Babb, on orchid plants.

Location of types: The holotype and two paratypes deposited in the Snow Entomological Museum, the allotype and one paratype at the United States National Museum.

Remarks: Except for the number of setae on the male genital plates, which vary from twelve to thirteen pairs, and a slight variation in the number of tactile setae on the leg segments, characters in this species appear to be constant. Total length varies from 902 μ to 994 μ. This species is named *longistriata* to call attention to the almost uninterrupted striae in the dorsal propodosomal pattern. Drawings of the holotype.

Bdella distincta Baker and Balock

(Figs. 41, 79, 80, 141)

Bdella distincta Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 179.

This species is closely related to *Bdella mexicana,* but has distally branched dorsal hysterosomal setae, rather than long nude or long plumose setae and has finely broken striae rather than sparsely broken to continuous striae on the dorsal propodosoma.

Female: Color in life unknown. Body narrowly ovoid, strongly constricted; length, including gnathosoma, 858 μ. *Gnathosoma:* Length, 202 μ; palpus (fig. 41) short, distal two thirds of tibiotarsus extending beyond hypostome; measurements: I, 10 μ; II plus III, 129 μ; IV, 29 μ; V, 54 μ; *des*, 139 μ; *ves*, 126 μ. Chelicera normal, finely striated, 187 μ in length; chela smooth, fixed digit attenuate, both digits of equal length; distal seta extending to base of chela, proximal seta extending half the distance to distal seta; setae inserted as in fig. 13. Hypostome nonstriated; ventral setae approximately equidistant, arranged in two longitudinal series, *vh 1* between palpal articulations; dorsal hypostomals slightly shorter than *vh 1*. *Dorsal propodosoma* (fig. 141): Striae finally broken; lateral propodosomals thickened, sparsely branched near apex, 51 μ in length, median propodosomals branched distally as in fig. 182, 53 μ in length, eyes separated by distance equal to diameter of anterior pair, space between eyes with transverse striae; distance between anterior sensilla, 95 μ. *Dorsal hysterosoma:* Setae branched distally, as in fig. 182; length of internal humeral, 49 μ, approximately one half of first interspace; external humeral, 61 μ in length; sacrals in gently curving transverse row, clunals in strongly curving transverse row. *Anal region:* Border striae bending laterad; one pair of anal setae near anterior termination of cleft; one pair of distally branched paranals posterior to laterally directed striae; postanals branched, flanking termination of cleft, slightly shorter than external clunals. *Genital region:* Each genital plate with 8 small, equal setae in linear arrangement: 9 pairs of paragenitals, anterior pair between coxae IV; genital discs small, anterior pair one fourth the length of vestibule from anterior end; two posterior pairs approximate, immediately caudad of middle of vestibule; ovipositor with 12 subapical, 6 postmedial setae. *Legs* (figs. 79, 80): Claws with one row of small lateral rays each; coxae nonstriated; measurements: tibia I, 51 μ; tarsus I, 75 μ; tibia II, 32 μ; tarsus II, 72 μ. Chaetotaxy: coxae I-IV, 5, 4, 4, 3 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 8, 9, 7, 3 tactile setae; telofemora I-IV, each with 1 large, dorsal, branched seta plus 4, 5, 5, 3 tactile setae; genu I, 4 tactiles, 2 attenuate sensory setae; genua II-IV, 5 tactile setae, 1 attenuate sensory seta each; tibia I, 7 tactiles, 3 attenuate sensory setae, 1 attenuate peg, trichoboth; tibia II, 8 tactiles, 1 attenuate and 1 blunt sensory seta; tibia III, 7 tactiles, 1 attenuate sensory seta; tibia IV, 7 tactiles, trichoboth; tarsus I, 10 plumose ventrals in 2 rows, 5 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt

sensory setae, 1 hollow, blunt peg, *dt 1* scaly, *dt 2, 3* minutely plumose; tarsus II, 8 plumose ventrals, 5 lateral and 1 dorsal tactile setae, 2 blunt sensory setae, 1 solid peg, dorsoterminals as in tarsus I; tarsus III, 8 plumose ventrals, 4 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 8 plumose ventrals, 4 laterals, trichoboth, 1 attenuate sensory seta distal to trichoboth, dorsoterminals as in tarsus I.

Male: Unknown.

Types: Female, China, at Washington, D. C., January 29, 1941, on *Bambusa parvariabilis* tree; female, Hawaii, at Houston, Texas, October 18, 1934, O. D. Morris, in pine cones. The specimen from China is herewith designated lectotype by the present author.

Location of types: The United States National Museum, type no. 1463.

Remarks: The material examined by the present writer included specimens with the following data: two females, Mexico, at Laredo, Texas, August 24, 1945, I. A. Lane, on *Croton* cuttings; one female, Guayama, Puerto Rico, October 20, 1941, G. N. Wolcott, on *Ficus stahlii*; one female, Philippines, at Honolulu, Hawaii, April 14, 1933, on *Saccolabium violaceum;* two nymphs, Indonesia, at Washington, D. C., April 19, 1954, H. Y. Goudeman, on camellia cuttings.

The characters distinguishing this species are stable. The length, including gnathosoma, varies from 688 μ to 858 μ, and the tactile setae on the leg segments vary from one more, to one less, than the numbers indicated in the redescription. Redescription and drawings of the lectotype.

Bdella mexicana Baker and Balock

(Figs. 13, 36, 81, 82)

Bdella mexicana Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 181.
Bdella willisi Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 182 (new synonym).

This species is closely related to *Bdella distincta*, but has sparsely broken to continuous striae in the dorsal propodosomal pattern, rather than finely broken striae. *Bdella mexicana* is unique among the known species of *Bdella* in that it lacks a trichoboth on tarsus IV.

Female: Color in life unknown. Body narrow, strongly constricted; length, including gnathosoma, 560 μ. *Gnathosoma:* Length, 183 μ; palpus (fig. 36) short, distal third of tibiotarsus extending beyond hypostome; measurements: I, 11 μ; II plus III, 79 μ; IV, 20 μ; V, 48 μ; *des,* 104 μ; *ves,* 73 μ. Chelicera (fig. 13) inflated, finely stri-

ated, 148 μ in length; chela dentate, one small tooth on movable digit, fixed digit attenuate, two thirds the length of movable digit; distal seta extending to base of chela, proximal seta extending two thirds the distance to distal seta, setae as figured. Hypostome nonstriated; ventral setae in two longitudinal series, *vh 1* between palpal articulations, setae in each row approximately equidistant; dorsal hypostomal setae equal in length to *vh 1*. *Dorsal propodosoma:* Striae sparsely broken, pattern similar to *Bdella distincta* (fig. 141); lateral propodosomals nude, 30 μ in length; median propodosomals nude, 34 μ in length; eyes separated by distance equal to one half the diameter of anterior pair, space between eyes with longitudinal striae; distance between anterior sensilla, 64 μ. *Dorsal hysterosoma:* Setae minutely plumose; length of internal humeral, 45 μ, approximately one half of first interspace; external humeral, 61 μ in length; sacrals and clunals in gently curving transverse rows. *Anal region:* Border striae bending laterad; one pair of anal setae anterior, one pair posterior of laterally directed striae; paranals wanting; postanals flanking termination of cleft, shorter than the clunal setae. *Genital region:* Each genital plate with 8 small, equal setae in linear arrangement inserted on a longitudinal, nonstriated area; 9 pairs of paragenitals, anterior pair between coxae IV, genital discs small, anterior pair one fourth the length of the vestibule from anterior end, posterior pairs approximate, immediately caudad of middle; ovipositor with 12 subapical, 6 postmedial setae. *Legs* (figs. 81, 82): Claws with one row of short, lateral rays each; measurements: tibia I, 42 μ; tarsus I, 44 μ; tibia II, 26 μ; tarsus II, 32 μ. Chaetotaxy: coxae I-IV, 5, 4, 5, 2 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 8, 7, 7, 5 tactile setae; telofemora I-IV, 5, 5, 5, 4 tactile setae; genua I-IV, 4 tactile setae, one attenuate sensory seta each; tibia I, 6 tactile setae, 3 attenuate sensory setae, trichoboth; tibia II, 5 tactile setae, one attenuate and one blunt sensory seta; tibia III, 5 tactile setae, one attenuate sensory seta; tibia IV, 5 tactile setae, trichoboth; tarsus I, 7 plumose ventrals arranged in 2 rows, 5 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, one solid, attenuate peg, *dt 1* solid, nude, *dt* 2, 3 solid, plumose; tarsus II, 6 plumose ventrals, 3 lateral and 1 dorsal tactile seta, 2 blunt sensory setae, one solid, attenuate peg, dorsoterminals as in tarsus I; tarsus III, 6 plumose ventrals, 3 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 6 plumose ventrals, 2 laterals, 1 attenuate sensory seta, trichoboth wanting, dorsoterminals as in tarsus I.

Male: Identical to female; amphioid sclerites each with five equal setae in gently curving longitudinal row on anterior half of plate, three smaller setae in oblique row approximately two thirds the length of the plate from the anterior end.

Type: Female, Valle del Bravo, México, Mexico, March 4, 1943, Donald Dodds, moss.

Location of type: The United States National Museum, type no. 1464.

Remarks: The type of *Bdella willisi* was also examined; this specimen, a male, was collected at Laguna de Zempoala, Morelos, Mexico, January 31, 1943, by E. W. Baker, in moss. Ten additional females were available and these included specimens from Mexico (San Luis Potosí, Veracruz) and the United States (Texas, Kansas, Illinois, Maryland, New York, Connecticut).

The dorsal hysterosomals are nude in the Mexican specimens, but pilose in the individuals collected in the United States. Intergrades between these two conditions were not discovered, but presumably, they might occur in a limited area near the Texas-Mexican border. In the study specimens, the number of tactile setae on the leg segments, especially the basifemora, vary from two more to one less than the number indicated in the description of the holotype. The total length varies from 560 μ to 675 μ, and the other measurements vary proportionately. Drawings of the *mexicana* type.

Odontoscirinae Grandjean, 1938

The Odontoscirinae is characterized by six or seven pairs of ventral hypostomal setae, five pairs of trichoboths, and the absence of genital tracheae. The palpal tibiotarsus is cylindrical and usually as long or longer than the palpal basifemur. The end setae are equal or subequal and usually shorter than the palpal tibiotarsus. Normal to inflated chelicerae bear one to many setae inserted on the proximal three fourths; the chelae have the movable digits sickle-shaped (straight in *Odontoscirus*). Lateral propodosomal setae may be present or absent; secondary apodemes are usually not developed, although large amounts of cuticular deposition may form large subcutaneous plates. The striation patterns on the dorsum of the propodosoma are similar in all genera; four eyes are lateral or posterolateral to the modified or unmodified posterior pseudostigmata. The podocephalic canal is an internal tube (Grandjean, 1938).

Genus *Odontoscirus* Thor

Biscirus (*Odontoscirus*) Thor, 1913, Zool. Anz., vol. 42, no. 1, p. 29. (Type: *Bdella virgulata* Canestrini and Fanzago, 1876 [by original designation].)

The modifications of the gnathosoma are characteristic for this distinctive genus. The chelicerae are inflated; the digits are approximately equal in length, and the movable digit is basically straight and dentate. The lateral lips are much larger than the same structures in other genera (except *Cyta*). The lateral propodosomal setae are wanting. The posterior pseudostigmatic organs are unmodified and the posterior sensilla are longer than the median propodosomal setae. Legs II are shorter than legs I.

KEY TO THE SPECIES OF ODONTOSCIRUS

1. Small; chelicerae and gnathosoma striated; palpal tibiotarsus with 4 tactile setae, 1 attenuate sensory seta, and 2 long apical setae *iota* p. 386

   Large; only gnathosomal base striated; palpal tibiotarsus with 6 tactile setae, 1 attenuate sensory seta, and 2 long apical setae *alpinus* p. 388

Odontoscirus iota, sp. nov.

(Figs. 9, 16, 17, 44, 83, 84, 154)

This species is related to *Odontoscirus virgulatus* (Canestrini and Fanzago), 1876, but is about 900 μ to 1100 μ rather than 1100 μ to 2000 μ in total length. The palpal tibiotarsus of *O. iota* is approximately 120 μ in length, as compared to the same structure of *O. virgulatus*, which is approximately 250 μ long.

Female: Color unknown. Body narrowly ovoid; length, including gnathosoma, 1100 μ. *Gnathosoma:* Length, 264 μ; palpus (fig. 44) relatively short, tibiotarsus extending beyond hypostome; measurements: I, 15 μ; II, 158 μ; III, 26 μ; IV, 22 μ; V, 117 μ; *des*, 145 μ; *ves*, 150 μ. Chelicera inflated, finely striated, 255 μ in length; chela (figs. 9, 17) dentate, movable digit with 4 small teeth, fixed digit with small subapical tooth, digits of same length; setae inserted as in fig. 16. Gnathosoma striated; ventral setae in two longitudinal series; *vh 1-5* approximately equidistant, *vh 6* medial between *vh 5* and apices of lateral lips, *vh 2* between palpal articulations; *vh 1* caudad; dorsal hypostomal setae equal in length to *vh 3*. *Dorsal propodosoma* (fig. 154): Striae finely broken; median propodosomals nude, 80 μ in length; eyes separated by a distance equal to two diameters of anterior pair; distance between anterior sensilla, 66 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 65 μ, approximately one half of first interspace; external humeral,

82 μ in length; sacrals in gently curving transverse row; clunals in subrectangular arrangement. *Anal region:* Border striae parallel; one pair of anal setae; paranals wanting; postanals flanking termination of cleft, shorter than clunal setae. *Genital region:* Each genital plate with 7 equal genital setae in linear arrangement; 3 pairs of paragenitals caudad of anterior termination of aperture; genital discs small, anterior pair slightly removed from proximate posterior pairs; ovipositor with 16 subapical, 6 postmedial setae. *Legs* (figs. 83, 84): Claws with 4-5 lateral rays each, minute rays wanting; measurements: tibia I, 68 μ; tarsus I, 155 μ; tibia II, 60 μ; tarsus II, 143 μ. Chaetotaxy: coxae I-IV, 5, 2, 4, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 11, 11, 7, 3 tactiles, 5 attenuate sensory setae; genu I, 6 tactiles, 5 attenuate sensory setae; genu II, 6 tactiles, 2 attenuate sensory setae; genua III-IV, 5 tactiles and 1 attenuate sensory seta each; tibia I, 10 tactiles, 4 attenuate and 1 blunt sensory seta, 1 peg, trichoboth; tibia II, 8 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 10 tactiles, 1 attenuate sensory seta; tibia IV, 9 tactiles, trichoboth; tarsus I, 14 plumose ventrals arranged in two rows, 6 lateral and 2 dorsal tactile setae, 1 attenuate and 3 blunt sensory setae, 1 peg, dorsal terminals, solid, plumose; tarsus II, ventrals, laterals, and dorsoterminals as in tarsus I, 1 dorsal tactile seta, 1 attenuate and 2 blunt sensory setae, 1 peg; tarsus III, ventrals, laterals, and dorsoterminals as in tarsus I, trichoboth; tarsus IV, ventrals and laterals as in tarsus I, trichoboth, *dt 1* reduced to 1 solid, plumose seta, *dt 2*, 3 solid, plumose.

Male: Identical to female; slightly longer than female; amphioid sclerites with 3, 1, 3, 2 setae each.

Holotype: Female, near Oakland, California (in hills), February 12, 1956, N. A. Walker, redwood.

Allotype: Male, Naperville, Illinois, January 24, 1931, C. C. Compton, in mushrooms.

Paratypes: Two females, same data as holotype.

Location of types: Holotype and paratypes deposited in the Snow Entomological Museum; the allotype deposited at the United States National Museum.

Remarks: Other than slight size differences, the only notable variation occurs in one female, which has ten pairs of setae on the genital plates, rather than seven pairs. This species is named *iota* to denote its small size when compared to the other described species of *Odontoscirus*. Drawings of the holotype.

Odontoscirus alpinus, sp. nov.

(Figs. 15, 43, 85, 86)

This species is closely related to *O. virgulatus* (Canestrini and Fanzago), 1876, but has three to four teeth on the movable digit of the chelicera instead of four to five teeth. Also, the palpal tibiotarsus of *alpinus* has two setae on the proximal half, whereas *virgulatus* has all of the setae restricted to the distal half of that segment.

Female: Color in life red with dark blue to black blotches. Body ovoid, weakly constricted; length, including gnathosoma, 1990 μ. *Gnathosoma:* Length, 533 μ; palpus (fig. 43) with tibiotarsus extending beyond hypostome; measurements: I, 12 μ; II, 189 μ; III, 26 μ; IV, 24 μ; V, 164 μ; *des,* 238 μ; *ves,* 238 μ. Chelicera normal, reticulated, 476 μ in length; digits equal in length, movable digit with 4-5 teeth, fixed digit with 1 subapical tooth; setae inserted medially (fig. 15). Gnathosomal base striated, buccal cone nonstriated; ventral setae in two longitudinal series, *vh 1-4* equidistant, interval between *vh 4-5* approximately twice the distance between *vh 2* and *3, vh 6* near the termination of buccal cone, *vh 2-4* inserted on the proximal half of the cone, *vh 1* on base; dorsal hypostomals equal in length to *vh 3. Dorsal propodosoma:* Striae finely broken; pattern similar to that of *Odontoscirus iota* (fig. 154); median propodosomals nude, approximately 100 μ in length; eyes separated by distance equal to four times the diameter of the anterior pair; distance between anterior sensilla, 78 μ. *Dorsal hysterosoma:* Setae finely plumose; length of internal humeral, 104 μ, approximately one third of first interspace; external humeral, 109 μ in length; sacrals in gently curving transverse row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel; one pair of anal setae; paranals wanting; postanals flanking termination of cleft, shorter than clunal setae. *Genital region:* Each genital plate with 7 equal attenuate setae in linear arrangement; 3 pairs of paragenitals; genital discs of medium size, proximate, in central area of vestibule; ovipositor with 16 subapical, 6 postmedial setae. *Legs* (figs. 85, 86): Claws with 6 lateral rays each, minute rays wanting; measurements: tibia I, 158 μ; tarsus I, 311 μ; tibia II, 151 μ; tarsus II, 298 μ. Chaetotaxy: coxae I-IV, 5, 3, 4, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 11, 13, 9, 3 tactile setae; telofemora I-IV, 7, 8, 7, 7 tactile setae; genu I, 6 tactiles, 6 attenuate sensory setae; genua II-IV, 6 tactile and 3 attenuate and two blunt sensory setae, 1 peg, *dt 1,* solid, nude,

setae, 1 peg, trichoboth; tibia II, 10 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 12 tactiles, 1 attenuate sensory seta; tibia IV, 13 tactiles, trichoboth; tarsus I, 22 plumose ventrals arranged in two rows, 10 lateral and 1 dorsal tactile seta, two attenuate and two blunt sensory setae, 1 peg, *dt 1*, solid, nude, *dt 2, 3* solid, plumose; tarsus II similar to tarsus I except lacking 1 lateral tactile seta and 1 attenuate sensory seta; tarsus III, 22 plumose ventrals, 9 laterals, dorsoterminals as in leg I, trichoboth; tarsus IV, similar to tarsus III, but *dt 1* reduced to 1 solid, nude seta.

Male: Unknown.

Holotype: Female, Piegan Pass, Glacier National Park, Montana, August 23, 1953, collector: Levi, altitude 7,900 ft.

Paratype: One female, same data as holotype.

Location of types: The holotype and paratype deposited in the Snow Entomological Museum.

Remarks: These specimens agree in general size with *O. virgulatus,* but the critical features for determination are lacking in the description of the European species. The paratype female is slightly smaller than the holotype, total length, 1030 μ, but the other features are constant. This new species is named *alpinus* because the only known specimens were collected at high altitudes. Drawings of the holotype.

Genus *Neomolgus* Oudemans

Neomolgus Oudemans, 1937, Kritisch Historisch Overzicht der Acarologie, Leiden, vol. 3, part C, p. 1229. (Type: *Acarus littoralis* L., 1758 [by original designation].)

Molgus Trouessart, 1894 (*non* Dujardin 1842, Murray 1877, Halacaridae) Jour. Ant. Physiol., vol. 30, p. 117. (Type: *Molgus sanguincus* Trouessart, 1894 [= *Acarus littoralis* L.] [by original designation].)

Molgus (*Hoplomolgus*) Berlese, 1923, Redia, vol. 15, p. 237 (new synonym). (Type: *Bdella capillata* Berlese, 1891 [*non* Kramer, 1881] [by original designation].)

This genus, which is related to *Bdellodes,* is characterized as having more than two setae on each chelicera. The chelicerae are normal; the movable digits are smooth or flattened distally on the inner surface, and are slightly longer than the fixed digits. The lateral propodosomal setae are wanting. The posterior pseudostigmata are unmodified and the posterior sensilla are longer than the median propodosomal setae. Legs II are shorter than legs I.

The subgenus *Hoplomolgus* was erected for species of *Neomolgus* (= *Molgus*) with distinct, reniform dorsal shields. These shields, formed by a large amount of cuticular deposition, are considered to be extreme modifications of a continuous character, *i. e.,* cuticular deposition.

KEY TO THE SPECIES OF NEOMOLGUS

1. Chelicera with 9-10 setae; palpal basifemur with 6-8 setae
littoralis p. 390
Chelicera with 6-8 setae; palpal basifemur with 3-4 setae
mutabilis p. 392

Neomolgus littoralis (L.)

(Figs. 29, 56, 107, 108)

Acarus littoralis Linnaeus, 1758, Syst. Nat., ed. 10, p. 618.

This species appears to be closely related to *N. capillatus* (Kramer), 1881. Although of comparable size, *N. littoralis* has fifteen to twenty-four setae on the palpal tibiotarsus rather than nine to eleven, and has long rather than short dorsal hysterosomal setae.

Female: Color in life dark red with irregular dark blue blotches. Body robust, weakly constricted; length, including gnathosoma, 2200 μ (2060-2345 μ). *Gnathosoma:* Length, 575 μ (518-660 μ); palpus (fig. 56) with genu two times longer than telofemur; measurements: I, 31 μ (29-34 μ); II, 422 μ (315-476 μ); III, 94 μ (65-119 μ); IV, 168 μ (122-185 μ); V, 400 μ (325-425 μ); *des,* 170 μ 146-170 μ); *ves,* 153 μ (119-158 μ). Chelicera (fig. 29) normal, nonstriated, 568 μ (511-617 μ) in length, with 10 (9-10) setae; movable digit with inner surface flattened apically, fixed digit extending to proximal termination of flattened surface of movable digit. Gnathosomal base striated, buccal cone nonstriated; ventral setae form two longitudinal rows, *vh 1-5* on proximal third of cone, *vh 6* medial between apex and *vh 5;* dorsal hypostomal setae as long as *vh 1. Dorsal propodosoma:* Striae finely broken; pattern similar to fig. 163, median propodosomals nude (to finely plumose), 235 μ (212-272 μ) in length; eyes separated by distance equal to 3 diameters of anterior pair, interval between eyes with transverse striae; distance between anterior sensilla, 119 μ (103-122 μ). *Dorsal hysterosoma:* Setae finely plumose; length of internal humeral, 174 μ (141-174 μ), approximately half of first interspace; external humeral, 243 μ (170-280 μ) in length; sacrals in gently curving transverse row, clunals in strongly curving transverse row. *Anal region:* Border striae parallel; anal setae wanting; three pairs of paranals; postanals flanking termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 12, approximately equal, attenuate setae in irregular linear arrangement; 7 paragenitals, anterior pair at level of anterior termination of aperture; genital discs large, anterior pair exceeding twice the length of the median pair; ovipositor with 20 subapical setae. *Legs* (figs. 107, 108): Claws with 7-8 lateral rays each; measurements: tibia I, 247 μ

(192-272 μ); tarsus I, 388 μ (308-425 μ); tibia II, 244 μ (187-260 μ); tarsus II, 383 μ (306-418 μ). Chaetotaxy: coxae I-IV, 11 (8-12), 11 (9-11), 13 (12), 12 (7-12) tactile setae; trochanters I-IV, 2, 2, 3 (2), 3 (4) tactile setae; basifemora I-IV, 13 (12-18), 13 (13-16), 11 (10), 8 (9) tactile setae; telofemora I-IV, 7 (7-11), 7 (8), 7 (8), 6 (7) tactile setae; genu I, 6 (6-9) tactile setae, 14 (9-14) attenuate sensory setae; genu II, 6 (6-8) tactile setae, 10 (5-11) attenuate sensory setae; genu III, 6 (5-7) tactile setae, 8 (5-8) attenuate sensory setae; genu IV, 8 (9) tactile setae, 5 (3-5) attenuate sensory setae; tibia I, 12 (11 18) tactile setae, 20 (13-23) attenuate sensory setae, 1 peg, trichoboth; tibia II, 12 (10-16) tactile setae, 13 (10-20) attenuate sensory setae, 1 blunt sensory seta, trichoboth; tibia III, 14 (14-16) tactile setae, 7 (4-9) attenuate sensory setae; tibia IV, 13 (13-14) tactile setae, 3 (1-4) attenuate sensory setae, trichoboth (may be absent); tarsus I, 28 (27-34) ventrals, distal pairs plumose, arranged in 4 rows, proximal pairs nude, in 2 rows, 10 (13) lateral, 2 dorsolateral and 2 dorsal tactile setae, 7 (5-7) attenuate sensory setae and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, coarsely plumose; tarsus II, identical to leg I, except lacking 1 dorsolateral tactile seta, *dt 2,* solid, nude; tarsus III, ventrals and laterals as in leg I, 3 attenuate sensory setae, trichoboth, dorsoterminals as in leg II; tarsus IV, similar to leg III, except 2 attenuate sensory setae, *dt 1* reduced to one seta.

Male: Identical to female; amphioid sclerites with 3, 4, 2 setae each.

Type: Europe.

Location of type: Unknown.

Remarks: Over one hundred and fifty specimens were examined, which included collections from: Alaska, Hudson Bay area, Greenland, Iceland, Spitsbergen, Bering Island, Russian Lapland (Kola-Hafvon), Nova Zembla (Matochkin Strait), and Finland.

The specimens from Matochkin Strait, four males, are of special interest. Typical in other characteristics, each of these mites lacks the trichoboth on tibia IV, a long tactile seta is inserted at the position normally occupied by the trichoboth.

Thor (1931) reports a greater variation in size and chaetotaxy in this species than indicated in the present study. Total length varies from 1500 μ to 3500 μ and other measurements vary accordingly. The setae of the palpus may vary as follows: II, 6-8; III, 1; IV, 5-7; V, 15-24 tactile setae. The redescription and illustrations are based on a female collected at Sanders Island, Greenland, August 4, 1952, J. M. Anderson, Ex: beach.

Neomolgus mutabilis, sp. nov.
(Figs. 28, 55, 111, 112, 163)

This species is closely related to *Neomolgus pallipes* (Koch), 1879, but can be distinguished by the number of setae on the palpal basifemur and chelicera, respectively, 3-4 rather than 5-6, and 6-8 rather than 8-10.

Female: Color in life unknown. Body ovoid, weakly constricted; length, including gnathosoma, 1660 μ. *Gnathosoma:* Length, 413 μ; palpus (fig. 55) with tibiotarsus approximately equal in length to basifemur, genu equal to telofemur; measurements: I, 23 μ; II, 216 μ; III, 34 μ; IV, 44 μ; V, 235 μ; *des,* 136 μ; *ves,* 124μ. Chelicera (fig. 28) normal, nonstriated with 7 setae, 371 μ in length; movable digit distally flattened on inner surface, fixed digit extending to proximal termination of flattened surface of movable digit. Gnathosomal base striated, buccal cone nonstriated; ventral setae form two longitudinal rows, *vh 1-5* approximate, equidistant, *vh 6* medial between apex and *vh 5;* dorsal hypostomal setae equal in length to *vh 2. Dorsal propodosoma* (fig. 163): Striae finely broken; median propodosomals plumose, 65 μ in length; eyes separated by distance equal to 3 diameters of anterior pair; interval between eyes with transverse striae; distance between anterior sensilla, 65 μ. *Dorsal hysterosoma:* Setae plumose; length of internal humeral, 43 μ, approximately one fourth of first interspace; length of external humeral, 53 μ; sacrals in gently curving transverse row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel, anals wanting; one pair of paranals; postanals flanking termination of cleft, equal in length to clunals. *Genital region:* Each genital plate with 8 progressively shorter setae in linear arrangement; five pairs of paragenitals, anterior pair between coxae IV; genital discs large, equidistant, in anterior three fourths of vestibule; ovipositor with 16 subapical and 4 postmedial setae. *Legs* (figs. 111, 112): Claws each with 4-6 lateral rays, one row of minute rays reduced in number; measurements: tibia I, 136 μ; tarsus I, 197 μ; tibia II, 129 μ; tarsus II, 187 μ. Chaetotaxy: coxae I-IV, 5, 5, 5, 3 tactile setae; trochanters I-IV, each with one tactile seta; basifemora I-IV, 10, 9, 7, 4 tactile setae; telofemora I-IV, 8, 7, 6, 6 tactile setae; genu I, 6 tactiles, 12 attenuate sensory setae; genu II, 6 tactiles, 5 attenuate sensory setae; genu III, 5 tactiles, 5 attenuate sensory setae; genu IV, 6 tactiles, 4 attenuate sensory setae; tibia I, 12 tactiles, 13 attenuate sensory setae, 1 peg, trichoboth; tibia II, 12 tactiles, 5 attenuate sensory setae, 1 blunt sensory seta, trichoboth; tibia III,

11 tactiles, 3 attenuate sensory setae; tibia IV, 11 tactiles, 3 attenuate sensory setae, trichoboth; tarsus I, 15 ventrals arranged in 2 rows, distal 11 plumose, 7 lateral and 2 dorsal tactile setae, 4 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* anterior to *dt 2*, solid, nude, *dt 3* between *dt 2* solid, plumose; tarsus II, 15 ventrals, distal 11 plumose, 6 lateral and 2 dorsal tactiles, 2 blunt sensory setae, 1 peg, *dt 1, 2* solid, nude, *dt 3* solid, plumose; tarsus III, ventrals and dorsoterminals as in leg II, 6 laterals, trichoboth; tarsus IV, 14 ventrals, distal 8 plumose, 5 laterals, trichoboth, *dt 1* reduced to 1 solid nude seta, *dt 2, 3* as in leg II.

Male: Closely resembles the female except in size, number of attenuate sensory setae and dorsal tactile setae on the legs and in the genital region. Length, including gnathosoma, 1320 μ, other measurements decrease accordingly; number of attenuate sensory setae: genua I-IV, 10, 6, 5, 4; tibiae I-IV, 11, 7, 3, 4; tarsus I with 3 dorsal tactile setae; each genital plate with 7 setae; amphioid sclerites with 3, 4, 2 setae each.

Holotype: Male, 2 miles south of Galena, Cherokee Co., Kansas, April 8, 1955, Ronald B. Winslow, under board.

Allotype: Female, 2 miles south of Galena, Cherokee Co., Kansas, April 8, 1955, W. T. Atyeo, under stone.

Paratypes: Four males, same data as holotype; one male, one female, same data as allotype; one male, one female, Univ. Kansas campus, Lawrence, Douglas Co., Kansas, April 22, 1952, R. E. Beer, under rock; three males, Univ. Kansas campus, collected respectively April 4, April 6, August 26, 1955, D. S. Narayan, under rocks; one male, Spring Hill, Johnson Co., Kansas, April 7, 1956, D. S. Lang, under rock; one male, 5 miles south of Avila Camacho, Distrito Federal, Mexico, July 3, 1956, R. E. Beer, moss (Berlese funnel extraction); one male, Mt. Popocatepetl, México, Mexico, August 18, 1954, W. T. Atyeo, beating lichens on trees, alt., 13,000 feet; one male, Denison, Texas, February 19, 1938, L. D. Christenson, in soil; one male, 13 miles east of Toluca, México, Mexico, August 17, 1954, W. T. Atyeo, under rocks.

Location of types: The holotype, allotype and thirteen paratypes are deposited in the Snow Entomological Museum; one paratype deposited at each of the following: the United States National Museum, the British Museum (Natural History) and the South Australian Museum.

Remarks: The chaetotaxy of the gnathosoma, genital plates and appendages exhibit considerable variation. The Mexican specimens

have one seta on the proximal half of the palpal tibiotarsus; specimens from the United States have two to three setae in this area. Sporadically, the palpal basifemora have an extra median seta, the chelicerae have six to eight setae, and the external genital flaps have seven to nine setae. The number of attenuate sensory setae on the legs varies as follows: telofemur I, 0-2; genua I-IV, 9-13, 5-6, 3-5, 2-4; tibiae I-IV, 6-13, 4-7, 2-5, 2-4. The attenuate sensory setae on telofemur I are of interest; this is one of the few species in which special sensory setae occur on the segments proximal to the genu. Total length varies from 944 μ to 1500 μ. This species is named *mutabilis* to indicate the extreme variability. Drawings are of the holotype.

Genus *Thoribdella* Grandjean

Thoribdella Grandjean, 1938, Ann. Soc. Ent. France, vol. 107, p. 4. (Type: *Biscirus meridionalis* Thor, 1931 [by original designation].)

This genus, which is probably closely related to *Bdellodes*, is distinguished by the deep goblet-shaped posterior pseudostigmatic organs and usually by the extreme reduction of the posterior sensilla. The chelicerae are normal and each has one or two setae. The inner surfaces of the movable digits are usually flattened distally, and are usually longer than the fixed digits. The lateral propodosomal setae may be present or absent. Legs II are as long or longer than legs I.

KEY TO THE SPECIES OF THORIBDELLA

1. Posterior sensilla longer than median propodosomal setae; distal cheliceral seta long, spinelike ..... *spinosa* p. 395
   Posterior sensilla much shorter than median propodosomal setae; distal cheliceral seta not spinelike 2
2. Posterior sensilla removed from median propodosomal setae; palpal genu twice as long as palpal telofemur ..... *californica* p. 396
   Posterior sensilla approximate to median propodosomal setae; palpal genu and telofemur of approximately equal lengths 3
3. Lateral propodosomal setae present ..... *insolita* p. 398
   Lateral propodosomal setae absent 4
4. Palpal genu with four setae; palpal tibiotarsus shorter than basifemur; internal humeral as long as first interspace ..... *communis* p. 399
   Palpal genu with three setae; palpal tibiotarsus as long as or longer than basifemur; internal humeral one third to one half of first interspace 5
5. Palpal basifemur three fourths the length of the tibiotarsus; posterior sensilla thickened, truncated ..... *truncata* p. 402
   Palpal basifemur and tibiotarsus of approximately equal lengths; posterior sensilla setaceous 6

6. Palpal tibiotarsus with seven setae (including end setae) restricted to distal half; cheliceral setae approximate ..... *meridionalis* p. 404
Palpal tibiotarsus with twelve setae (including end setae) not restricted to distal half; cheliceral setae distant ..... *simplex* p. 405

Thoribdella spinosa sp. nov.

(Figs. 27, 54, 109, 110, 143)

This unique species has the distal cheliceral seta modified into a long, thickened, spinelike structure which is bifid at the base, thus forming a short basal branch. The posterior sensilla are distant from, and longer than the median propodosomal setae.

Female: Color unknown. Body ovoid, weakly constricted; length, including gnathosoma, 1000 μ. *Gnathosoma:* Length, 391 μ; palpus (fig. 54) short, distal five sixths of tibiotarsus extending beyond hypostome; measurements: I, 14 μ; II, 182 μ; III, 36 μ; IV, 49 μ; V, 150 μ; *des*, 185 μ; *ves*, 160 μ. Chelicera (fig. 27) normal, nonstriated, 306 μ in length; chela smooth; distal seta large with short basal branch, proximal seta fine, approximate. Gnathosomal base, proximal third of buccal cone striated, distal two thirds nonstriated; *vh 1* inserted between palpal articulations, *vh 1-5* equidistant, arranged in 2 longitudinal series, *vh 6*, medial to series, midway between *vh 5* and apex; dorsal hypostomal setae shorter than *vh 1*. *Dorsal propodosoma:* Striae finely broken, pattern similar to fig. 142; median propodosomals nude (fig. 143), 54 μ in length; posterior sensilla fine, 85 μ in length, distant from median propodosomals; eyes separated by distance equal to two and one half diameters of anterior pair; distance between anterior sensilla, 73 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 66 μ, approximately one half of first interspace; external humeral, 66 μ in length; sacrals in gently curving row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel; 1 pair of anal setae, paranals wanting; postanals flanking termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 7 equal setae in linear arrangement; 2 pairs of paragenitals; anterior 2 pairs of genital discs large, proximate, posterior pair small, near caudal termination of vestibule; ovipositor with 14 subapical, 6 postmedial setae. *Legs* (figs. 109, 110): Claws with 5-6 lateral rays each, row of minute rays wanting; measurements: tibia I, 71 μ; tarsus I, 214 μ; tibia II, 73 μ; tarsus II, 216 μ. Chaetotaxy: coxae I-IV, 4, 2, 2, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 11, 8, 5, 3 tactile setae; telofemora I-IV, 6, 6, 5, 4 tactile setae; genu I, 4 tactiles, 6 attenuate sensory setae; genu II,

4 tactiles, 3 attenuate sensory setae; genu III, 3 tactiles, 1 attenuate sensory seta; genu IV, 4 tactiles, 1 attenuate sensory seta; tibia I, 7 tactiles, 3 attenuate sensory setae, trichoboth; tibia II, 7 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 7 tactiles, 1 attenuate sensory seta; tibia IV, 6 tactiles, trichoboth; tarsus I, 14 ventrals arranged in 2 rows, distal 12 plumose, 7 lateral and no dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus II, similar to tarsus I but lacking attenuate sensory setae; tarsus III, ventrals and dorsoterminals as in tarsus I, 2 laterals, 4 large dorsolaterals, trichoboth; tarsus IV, ventrals as in tarsus I, 4 large dorsolaterals, trichoboth, *dt 1* reduced to one solid, nude seta, *dt 2, 3* solid, plumose.

Male: Unknown.

Holotype: Female, Sierra del Rosario: El Rangel, Cuba, January, 1938, Alex Bierig, en hojarasca.

Location of type: The Snow Entomological Museum.

Remarks: The unique structure of the larger cheliceral seta and the relative positions and lengths of the posterior sensilla and median propodosomal setae, warrants the naming of this species, even though based on a single specimen. The name *spinosa* is chosen to emphasize the peculiar form of the cheliceral seta. Drawings of the holotype.

Thoribdella californica (Banks), new combination

(Figs. 25, 52, 105, 106, 144)

Bdella californica Banks, 1904, Proc. California Acad. Sci., ser. 3, vol. 3, no. 13, p. 366.

Bdella magna Ewing, 1913, J. Ent. Zool., vol. 5, p. 123 (new synonym).

This species is related to *T. simplex,* sp. nov., but has the palpal genu twice as long as the telofemur rather than the two segments of approximately equal length.

Male: Color in life red, with dark blue areas. Body ovoid, weakly constricted; length, including gnathosoma, 1880 μ. *Gnathosoma:* Length, 497 μ; palpus (fig. 52) with genu approximately twice the length of the telofemur; measurements: I, 24 μ; II, 306 μ; III, 78 μ; IV, 122 μ; V, 325 μ; *des,* 221 μ; *ves,* 146 μ. Chelicera (fig. 25) normal, nonstriated, 483 μ in length; inner face of movable digit flattened distally; setae as figured. Gnathosomal base striated, buccal cone nonstriated; *vh 1-6* in linear series, *vh 1-5* progressively more distant, *vh 6* midway between *vh 5* and base of lateral lips; dorsal hypostomal setae thickened, half the length of *vh 1. Dorsal*

propodosoma: Striae finely broken, pattern similar to fig. 142; median propodosomals (fig. 144) with almost parallel margins, 331 μ in length; posterior sensilla fine, distant from median propodosomals, 51 μ in length; eyes separated by distance equal to one and one half diameters of anterior pair; distance between anterior sensilla, 100 μ. *Dorsal hysterosoma:* Setae minutely pilose; length of internal humeral about 153 μ, approximately half of first interspace; external humerals broken, length unknown; sacrals and clunals respectively in gently and strongly curving transverse rows. *Anal region:* Border striae parallel; anal setae wanting; one pair of paranals; postanals flanking termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 10 unequal setae in linear arrangement, anterior 7 longer than posterior 3 setae; 3 pairs of paragenitals; genital discs of medium size, equidistant; amphioid sclerites with 3, 1, 4, 1 setae each. *Legs* (figs. 105, 106): Claws with 5-7 lateral rays each, row of minute rays wanting; measurements: tibia I, 184 μ; tarsus I, 318 μ; tibia II, 201 μ; tarsus II, 331 μ. Chaetotaxy: coxae I-IV, 4, 3, 4, 3 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 13, 13, 8, 4 tactile setae; telofemora I-IV, 8, 8, 6, 6 tactile setae; genu I, 7 tactiles, 5 attenuate sensory setae; genu II, 6 tactiles, 1 attenuate sensory seta; genua III-IV, 6 tactiles and 2 attenuate sensory setae each; tibia I, 14 tactiles, 6 attenuate sensory setae, 1 attenuate-blunt sensory seta, 1 peg, trichoboth; tibia II, 11 tactiles, 2 attenuate sensory setae, 1 blunt sensory seta, trichoboth; tibia III, 12 tactiles, 1 attenuate sensory seta; tibia IV, 12 tactiles, trichoboth; tarsus I, approximately 60 ventrals, distal two thirds plumose and arranged in 5-6 irregular rows, proximal third nude and arranged in 4 irregular rows, 9 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus II, approximately 50 ventrals arranged as in tarsus I, 10 lateral tactiles, 1 attenuate and 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, 40 ventrals, proximal half nude and arranged in 2 irregular rows, distal half plumose, in 4 irregular rows, 9 laterals, trichoboth, dorsoterminals similar to tarsus I; tarsus IV, ventrals and laterals as in tarsus III, trichoboth, *dt 1* reduced to 1 solid, nude seta, *dt 2, 3* solid, plumose.

Female (incomplete specimen): Similar to male; genital plates with 8 pairs of setae; ovipositor with 22 setae of indeterminable position.

Type: Claremont, Los Angeles Co., California.

Location of type: Unknown.

Remarks: Two cotypes of *Thoribdella magna* (Banks), 1913 (= *Bdella magna*), one from the United States National Museum and one from the Illinois Natural History Survey, were available for examination. As these two specimens, both females, were incomplete, it is impossible to determine whether or not any differences exist between the sexes other than the number of genital setae.

This species illustrates a distinct modification of the dorsal propodosomal setae. The reduced posterior sensilla are inserted in simple, straight-sided cups, and are distant from the long, almost parallel-margined median propodosomals. Drawings and redescription are based on a male collected at Oakland, Alameda Co., California, January 30, 1953, W. C. Bentinck, habitat unknown.

Thoribdella insolita, sp. nov.

(Figs. 26, 53, 99, 100, 148)

This unique species has four pairs of dorsal propodosomal setae and seven pairs of ventral hypostomal setae. Although reminiscent of *Octobdellodes* species, *insolita* has the posterior sensilla modified to structures typical of the genus *Thoribdella.* At the present time, the lateral propodosomal setae are sufficient to distinguish this new species.

Female: Color in life unknown. Length, including gnathosoma, 1540 μ. *Gnathosoma:* Length, 468 μ; palpus (fig. 53) short, only half of the tibiotarsus extending beyond gnathosoma; measurements: I, 25 μ; II, 209 μ; III, 46 μ; IV, 53 μ; V, 190 μ; *des,* 277 μ; *ves,* 216 μ. Chelicera (fig. 26) normal, nonstriated, 442 μ in length; movable digit with inner surface distally flattened; fixed digit with preapical tooth, setae as figured. Gnathosoma striated to level of *vh 6,* distally nonstriated; *vh 1-6* approximately equidistant, in 2 longitudinal series; dorsal hypostomals about half the length of *vh 1. Dorsal propodosoma:* Striae finely broken, pattern similar to fig. 142, except a pair of lateral propodosomal setae inserted anterad of posterior sensilla, approximately one fourth the interval between posterior sensilla and anterior sensilla; lateral propodosomals nude, 146 μ in length; median propodosomals (fig. 148) with basal flange, 442 μ in length; posterior sensilla approximate to median propodosomals, 36 μ in length; eyes separated by distance equal to one and one half diameters of anterior pair; distance between anterior sensilla, 91 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral approximately 187 μ, slightly longer than first interspace; external humeral, 206 μ in length; sacrals and clunals respectively,

in gently and strongly curving transverse rows. *Anal region:* Border striae parallel; anal setae and postanals wanting; 2 pairs of paranals. *Genital region:* Each genital plate wtih 6 equal, long setae in linear arrangement; 3 pairs of paragenital setae; genital discs small, caudal pair near termination of vestibule, distant from anterior pairs; ovipositor with 20 setae of indeterminable position. *Legs* (figs. 99, 100): Claws with 5 lateral rays each, row of minute rays wanting; measurements: tibia I, 119 μ; tarsus I, 349 μ; tibia II, 129 μ; tarsus II, 349 μ. Chaetotaxy: coxae I-IV, 3, 2, 3, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 12, 11, 9, 2 tactile setae; telofemora I-IV, 5, 5, 4, 4 tactile setae; genu I, 4 tactiles, 3 attenuate sensory setae; genu II, 4 tactiles, 1 attenuate sensory seta; genu III, 4 tactiles, 1 attenuate sensory seta; genu IV, 4 tactiles; tibia I, 8 tactiles, 3 attenuate sensory setae, trichoboth; tibia II, 8 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 8 tactiles, 1 attenuate sensory seta; tibia IV, 12 tactiles, trichoboth; tarsus I, 20 ventral setae arranged in 2 rows, distal 15 plumose, 10 lateral and 2 dorsal tactile setae, 1 attenuate and 2 blunt sensory setae, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus II, 18 ventrals, 10 laterals, 1 dorsal tactile seta, 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, 17 ventrals, 9 laterals, trichoboth, 1 long, attenuate peg distal to trichoboth; dorsoterminals as in tarsus I; tarsus IV, 20 ventrals, 2 lateral and 4 long, dorsolateral tactile setae, trichoboth, *dt 1* reduced to one solid, nude seta, *dt 2, 3* solid, plumose.

Male: Unknown.

Holotype: Female, 2 miles west of Oakville, Napa Co., California, December 31, 1953, G. A. Marsh, V. D. Roth, R. O. Schuster, "Laurel association."

Location of type: The Snow Entomological Museum.

Remarks: The posterior sensilla are reduced as in other *Thoribdella* species, but lateral propodosomal setae are present. In known species of the Odontoscirinae, only *Octobdellodes* species and this new *Thoribdella* species are characterized as having the lateral propodosomal setae present. Due to the unusual presence of these setae, this new species is called *insolita.* Drawings of the holotype.

Thoribdella communis, sp. nov.

(Figs. 22, 48, 97, 98, 146)

This species appears to be related to *T. truncata*, sp. nov., but the internal humerals are as long as the first interspaces and the palpal

basifemur is longer than the tibiotarsus. In *T. truncata* the internal humerals are about one third of the first interspaces and the palpal basifemur is three fourths the length of the tibiotarsus.

Female: Color in life dark red. Body robust, ovoid, weakly constricted; length, including gnathosoma, 1730 μ. *Gnathosoma*: Length, 775 μ; palpus (fig. 48) with basifemur longer than tibiotarsus; measurements: I, 27 μ; II, 265 μ; III, 44 μ; IV, 51 μ; V, 221 μ; *des*, 267 μ; *ves*, 197 μ. Chelicera (fig. 22) normal, nonstriated, 447 μ in length; movable digit with inner surface apically flattened, fixed digit with small subapical tooth, setae as figured. Gnathosomal base striated, buccal cone nonstriated, punctate; ventral setae forming two longitudinal series, *vh 1-5* equidistant on proximal one third of cone, *vh 6* premedial between apex and *vh 5;* dorsal hypostomal setae approximately equal in length to *vh 3*. *Dorsal propodosoma:* Striae finely broken; pattern similar to fig. 142; posterior sensilla approximate to base of median propodosomals, 36 μ in length; enlarged bases of median propodosomals pilose (fig. 146); length of median propodosomals approximately 364 μ; eyes separated by a distance equal to 3 diameters of anterior pair; distance between anterior sensilla, 87 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 170 μ, approximately three fourths of first interspace; external humeral about 175 μ in length; sacrals in gently curving transverse row, external clunals absent. *Anal region:* Border striae parallel; 2 pairs of anals, 1 pair of paranals; postanals wanting. *Genital region:* Each genital plate with 7 equal genital setae in linear arrangement; three pairs of paragenitals; genital discs small, equidistant, in central area of vestibule walls; ovipositor with 16 subapical, 4 postmedial setae. *Legs* (figs. 97, 98): Claws with 6-7 lateral rays each, row of minute rays wanting; measurements: tibia I, 136 μ; tarsus I, 359 μ; tibia II, 138 μ; tarsus II, 369 μ. Chaetotaxy: coxae I-IV, 4, 3, 4, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 13, 12, 8, 4 tactile setae; telofemora I-IV, 8, 8, 7, 6 tactile setae; genu I, 6 tactiles, 5 attenuate sensory setae; genu II, 5 tactiles, 4 attenuate sensory setae; genu III, 5 tactiles, 2 attenuate sensory setae; genu IV, 5 tactiles, 2 attenuate sensory setae; tibia I, 10 tactiles, 3 attenuate sensory setae, 1 peg, trichoboth; tibia II, 10 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 11 tactiles, 1 attenuate sensory seta; tibia IV, 12 tactiles, trichoboth; tarsus I, 22 plumose ventrals arranged in 2 rows, 10 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid,

nude, *dt 2, 3* solid, plumose; tarsus II, 21 ventrals as in tarsus I, 10 lateral tactiles, 1 dorsal tactile, 1 attenuate and 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsi III-IV, 21 ventrals as in tarsus I, 8 laterals, trichoboth, *dt 1* reduced to 1 solid, nude seta, *dt 2, 3* solid, plumose on tarsus IV.

Male: Identical to female except larger; length, including gnathosoma, 1560 μ; amphioid sclerites with 3, 4, 2 setae each.

Holotype: Male, west slope of Cortez Pass, México, Mexico, August 11, 1954, W. T. Atyeo, under rock, altitude 13,000 feet.

Allotype: Female, west slope of Cortez Pass, México, Mexico, August 11, 1954, W. T. Atyeo, moss (Berlese funnel extraction).

Paratypes: Two males, four females, same data as holotype; five males, twelve females, 4 miles west of San Cristobal de las Casas, México, Mexico, July 11, 1955, R. E. Beer, under rocks; two males, 5 miles south of Avila Camacho, Distrito Federal, Mexico, July 3, 1956, R. E. Beer, on bunch grass, *Epicamees* sp.; one male, 16 miles north of Juchitan, Oaxaca, Mexico, July 4, 1955, R. E. Beer, under rock; one female, 7 miles north of Cuernavaca, Morelos, Meixco, August 14, 1954, W. T. Atyeo, beating lichens, altitude 9,000 ft.; one female, twenty miles west of México (city), Mexico, July 31, 1954, W. T. Atyeo, under rock, altitude 9,000 ft.; one female, 7 miles northeast of Jacala, Hidalgo, Mexico, July 27, 1954, W. T. Atyeo, under log.

Location of types: The holotype, allotype, and twenty-three paratypes deposited in the Snow Entomological Museum. Two paratypes deposited in each of the following: the South Australian Museum, the British Museum (Natural History), and the United States National Museum.

Remarks: The total length of the majority of the specimens is between 1350 μ to 1700 μ, however, one female from the San Cristobal series measures about 2200 μ. Other measurements of the larger specimens are proportional to total length, for example, the palpal measurements of the extremely large female are: I, 30 μ; II, 337 μ; III, 63 μ; IV, 66 μ; V, 267 μ; *des*, 315 μ; *ves*, 255 μ.

The number of setae on the palpal basifemur varies from six to nine, and on the tibiotarsus, two specimens of the paratype series have a fourth seta in the median proximal row. Variations in the number of tactile setae on the leg segments are slight, and there may be five or six attenuate sensory setae on genu I. Individuals of this species are abundant in Mexico, hence the name of *communis*. Drawings of the holotype.

Thoribdella truncata, sp. nov.

(Figs. 24, 50, 101, 102, 149, 150)

This species is related to *T. communis*, sp. nov., but has highly modified posterior sensilla (fig. 150) and internal humerals one third the length of the first interspaces, rather than small, setaceous sensilla and internal humerals equal to the first interspaces.

Female: Color in life unknown; body ovoid, weakly constricted; length, including gnathosoma, 1560 μ. *Gnathosoma:* Length, 384 μ; palpus (fig. 50) with basifemur shorter than tibiotarsus; measurements: I, 17 μ; II, 153 μ; III, 53 μ; IV, 53 μ; V, 182 μ; *des*, 122 μ; *ves* 97 μ. Chelicera (fig. 24) normal, nonstriated, 333 μ in length; movable digit with inner surface distally flattened; setae as figured. Gnathosomal base and proximal third of buccal cone striated; distal two thirds of cone nonstriated; *vh 1-6* in two longitudinal series, *vh 1* inserted between palpal articulations, *vh 1-5* equidistant, *vh 6* approximately median between *vh 5* and apex; dorsal hypostomal setae half the length of *vh 1*. *Dorsal propodosoma:* Striae finely broken; pattern similar to fig. 142; median propodosomals (fig. 149), 289 μ in length; posterior sensilla, 12 μ in length, modified as in fig. 150; eyes separated by distance equal to two diameters of anterior pair; distance between anterior sensilla, 83 μ. *Dorsal hysterosoma*: Setae finely pilose; length of internal humeral, 65 μ, approximately one third of first interspace; external humeral, 65 μ in length; sacrals and clunals respectively in gently and strongly curving transverse rows. *Anal region:* Border striae parallel; one pair of anal setae; paranals wanting; postanals flanking termination of cleft, shorter than clunal setae. *Genital region:* Eight small, unequal setae in linear arrangement, anterior 3 longer than posterior 5, two pairs of paragenitals; genital discs small, equidistant; ovipositor with 16 subapical, 4 postmedial setae. *Legs* (figs. 101, 102): Claws with 6-7 lateral rays, one row of minute rays each; measurements: tibia I, 121 μ; tarsus I, 289 μ; tibia II, 122 μ; tarsus II, 291 μ. Chaetotaxy: coxae I-IV, 4, 4, 5, 4 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 17, 13, 10, 6 tactile setae; telofemora I-IV, 8, 7, 6, 5 tactile setae; genu I, 5 tactiles, 7 attenuate sensory setae; genu II, 6 tactiles, 6 attenuate sensory setae; genu III, 5 tactiles, 5 attenuate sensory setae; genu IV, 6 tactiles, 3 attenuate sensory setae; tibia I, 12 tactiles, 5 attenuate sensory setae, 1 blunt sensory seta, 1 apically forked peg, trichoboth; tibia II,

12 tactiles, 3 attenuate sensory setae, 1 blunt sensory seta, trichoboth; tibia III, 13 tactiles, 6 attenuate sensory setae; tibia IV, 14 tactiles, trichoboth; tarsus I, 36 plumose ventrals arranged in 2 rows proximally, to five irregular series distally, 15 lateral and 2 dorsal tactiles, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1*, solid, nude, *dt 2, 3* solid, plumose; tarsus II, 36 ventrals as in tarsus I, 12 lateral and 2 dorsal tactiles, 1 attenuate and 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, ventrals, laterals, dorsoterminals as in tarsus I, trichoboth; tarsus IV, ventrals, laterals, *dt 2, 3* as in tarsus I, trichoboth, *dt 1* reduced to 1 solid, nude seta.

Male: Identical to female except in general size; total length, including gnathosoma, 1350 μ, other measurements vary accordingly; amphioid sclerites with 3, 1, 3, 2 setae each.

Holotype: Male, 38 miles northeast of Montemorelos, Nuevo Leon, Mexico, August 4, 1955, R. E. Beer, under rock.

Allotype: Female, same data as holotype.

Paratypes: One male, same data as holotype; two females, 3 miles west of Antiguo Morelos, Tamaulipas, Mexico, R. E. Beer, August 3, 1955, under rocks; one male, Teziutlan, Pueblo, Mexico, July 22, 1955, R. E. Beer, hand picked from litter on forest floor; one female, Vera Blanca, Costa Rica, entre los volcanes Poás y Barba, altitude 2,000 m. s. m., August, 1938, Alex Bierig.

Location of types: The Snow Entomological Museum.

Remarks: In the Mexican series, the only notable variation is the number of attenuate sensory setae on tibia II. The specimens from Montemorelos and one from Antiguo Morelos have three attenuate sensory setae on tibia II of one side of the body and two setae on the other side; in the other specimens, the number of setae is the same on both sides, either two or three.

The Costa Rican specimen is larger than the Mexican specimens, measuring 1880 μ in total length. This specimen has a simple peg and nine attenuate sensory setae on tibia I, rather than a bifurcate peg and five attenuate sensory setae. Other segments of the legs also have an increased number of setae, while the genital plates have nine pairs of setae, instead of eight.

To indicate the unique modification of the posterior sensilla, this species is named *truncata*. Drawings of the holotype.

Thoribdella meridionalis (Thor)

(Figs. 21, 51, 95, 96, 145)

Biscirus (*Biscirus*) *meridionalis* Thor, 1931, Zool. Anz., vol. 92, no. ½, pp. 74-76.

This species is closely related to *Thoribdella norvegicus* (Thor), 1913 (= *Biscirus* (*B.*) *norvegicus*), but is much smaller, as indicated by the palpal measurements given for *norvegicus* (Thor, 1931): I, 25 μ; II, 460 μ; III, 88 μ; IV, 136 μ; V, 33 μ. The relative lengths of the palpal telofemur and genu may be used to differentiate these species, *T. meridionalis* having the segments approximately equal, and *norvegicus* with the fourth segment almost twice as long as the third.

Female: Color unknown; length, including gnathosoma, 866 μ (852-1143 μ). *Gnathosoma:* Length, 218 μ (218-277 μ); palpus (fig. 51) short, about half of tibiotarsus extending beyond hypostome; measurements: I, 12 μ (12-15 μ); II, 94 μ (94-129 μ); III, 22 μ (20-26 μ); IV, 24 μ (24-31 μ); V, 78 μ (71-109 μ); *des,* 107 μ (107-129 μ); *ves,* 97 μ (94-117 μ). Chelicera (fig. 21) normal, nonstriated, 204 μ (201-247 μ) in length; movable digit flattened distally on inner surface; setae as figured. Gnathosomal base striated, buccal cone nonstriated; *vh 1-5* equidistant, in 2 longitudinal series on proximal third of cone, *vh 6* mesad to series, midway between *vh 5* and apex of cone; dorsal hypostomal setae half the length of *vh 2*. *Dorsal propodosoma:* Striae finely broken, pattern similar to fig. 142; median propodosomals (fig. 145) enlarged basally, 162 μ (158-184 μ) in length; posterior sensilla thin, approximate to medial propodosomals, 17 μ (15-17 μ) in length; eyes separated by distance equal to two and one-half diameters of anterior pair; distance between anterior sensilla, 53 μ (44-53 μ). *Dorsal hysterosoma:* Setae nude; length of internal humeral, 63 μ (51-68 μ), approximately one half of first interspace; external humeral, 66 μ (53-68 μ) in length; sacrals and clunals respectively in gently and strongly curving transverse rows. *Anal region:* Border striae parallel, anals wanting, 1 pair of paranals, postanals flanking termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 5 (5-7) small, equal setae in linear arrangement; 3 pairs of paragenitals; ovipositor with 16 subapical, 4 postmedial setae. *Legs* (fig. 96): Claws with 4-5 lateral rays each, row of minute rays wanting; measurements: tibia I, 53 μ (53-65 μ); tarsus I, 136 μ (136-179 μ); tibia II, 53 μ (53-66 μ); tarsus II, 134 μ (134-170 μ). Chaetotaxy: coxae I-IV, 4, 2, 3, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 9, 7, 5, 3 tac-

tile setae; telofemora I-IV, 5, 5, 4, 4 tactile setae; genu I, 4 tactiles, 5 (6) attenuate sensory setae; genu II, 4 tactiles, 3 attenuate sensory setae; genu III, 4 tactiles, 2 (3) attenuate sensory setae; genu IV, 4 tactiles, 3 attenuate sensory setae; tibia I, 7 tactiles, 3 attenuate sensory setae, 1 peg, trichoboth; tibia II, 6 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 7 tactiles, 1 attenuate sensory seta; tibia IV, 7 tactiles, trichoboth; tarsus I, 12 plumose ventrals in 2 rows, 6 lateral and 1 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2*, 3 solid, plumose; tarsus II, similar to tarsus I but lacking the 2 attenuate sensory setae; tarsus III, 13 plumose ventrals, 5 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 15 ventrals, 4 laterals, trichoboth, *dt 1* reduced to 1 solid, nude seta, *dt 2*, 3 solid, plumose. Male: Not examined.

Type: Male, near Tange, North Africa, January, 1931, F. Grandjean, vegetable debris under bush.

Location of type: Unknown.

Remarks: The redescription is based on thirteen females collected in the United States (Maryland, Connecticut, Kansas, Michigan, California), Iceland, Sweden (Västerbotten), and Germany (Ost-Holstein). The specimens from Germany have an extra seta on the palpal tibiotarsus, but other than this exception, all the specimens coincide with the redescription. Illustrations were prepared from a female with the following data: Patuxent Wildlife Refuge, Maryland, R. O. Drummond, February 23, 1955, *Peromyscus leucopus noveboracensis* nest, no. 27.

Thoribdella simplex, sp. nov.

(Figs. 8, 23, 49, 103, 104, 147)

The approximately equal lengths of the palpal telofemur and genu distinguish this species from the related *T. californica*, in which the genu is twice as long as the telofemur.

Female: Color unknown. Body ovoid, weakly constricted; length, including gnathosoma, 2100 μ. *Gnathosoma:* Length, 572 μ; palpus (fig. 49) with tibiotarsus extending beyond hypostome; measurements: I, 31 μ; II, 289 μ; III, 68 μ; IV, 88 μ; V, 292 μ; *des*, 218 μ; *ves*, 167 μ. Chelicera (figs. 8, 23) normal, nonstriated, 568 μ in length; inner surface of movable digit flattened distally; setae as figured. Gnathosomal base and buccal cone to level of *vh 3* striated, distal portion of cone nonstriated; *vh 1-6* in 2 longitudinal series, *vh 1*, 2 between palpal articulations, *vh 1-4* equidistant, *vh*

5 slightly removed distally, *vh 6* medial between *vh 5* and apex; dorsal hypostomal setae longer than any member of *vh* series. *Dorsal propodosoma:* Striae finely broken, pattern similar to fig. 142; median propodosomal basally expanded (fig. 147), 349 μ in length; posterior sensilla thin, 36 μ in length, approximate to median propodosomals; eyes separated by distance equal to two diameters of anterior pair; distance between anterior sensilla, 104 μ. *Dorsal hysterosoma:* Setae plumose; length of internal humeral, 85 μ, approximately one third of first interspace; external humeral, 94 μ in length; sacrals and clunals respectively in gently and strongly curving transverse rows. *Anal region:* Border striae parallel; anal setae wanting; one pair of paranals; postanals flanking termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 9 unequal setae in linear arrangement, anterior 3 slightly larger than posterior 6 setae; 3 pairs of paragenitals; genital discs equidistant, anterior 2 pairs large, posterior pair small; ovipositor with 16 subapical, 4 postmedial setae. *Legs* (figs. 103, 104): Claws with 6-7 lateral rays each, row of minute rays wanting; measurements: tibia I, 218 μ; tarsus I, 394 μ; tibia II, 227 μ; tarsus II, 404 μ. Chaetotaxy: coxae I-IV, 4, 3, 4, 3 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 16, 15, 12, 5 tactile setae; telofemora I-IV, 11, 10, 10, 6 tactile setae; genu I, 7 tactiles, 12 attenuate sensory setae; genu II, 6 tactiles, 6 attenuate sensory setae; genua III-IV, 6 tactiles, 4 attenuate sensory setae each; tibia I, 13 tactiles, 14 attenuate sensory setae, 1 blunt sensory seta, 1 peg, trichoboth; tibia II, 14 tactiles, 6 attenuate sensory setae, 1 blunt sensory seta, trichoboth; tibia III, 13 tactiles, 1 attenuate sensory seta; tibia IV, 14 tactiles, trichoboth; tarsus I, 48 plumose ventrals arranged in 4 irregular rows, 12 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus II, similar to tarsus I, except lacking 1 lateral tactile seta and 2 attenuate sensory setae; tarsus III, 44 ventrals, 10 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 44 ventrals, 9 laterals, trichoboth, *dt 1* reduced to 1 solid, nude seta, *dt 2, 3* solid, plumose.

Male: Identical to female except in the chaetotaxy of the palpal basifemur, the number of attenuate sensory setae on legs I and II, and general size. Measurements: total length, 1605 μ; palpus: I, 25 μ; II, 224 μ; III, 43 μ; IV, 56 μ; V, 272 μ; *des*, 213 μ; *ves*, 158 μ; tibia I, 143 μ; tarsus I, 313 μ; tibia II, 146 μ; tarsus II, 322 μ; chelicera, 412 μ; gnathosoma, 433 μ; median propodosomals, 328 μ; posterior sensilla, 34 μ; distance between anterior sensilla, 77 μ. Palpal

basifemur with 5 setae; each genital plate with 10 setae; amphioid sclerites with 3, 1, 3, 1 setae each; genua I-II, 15 tactile setae, 9 attenuate sensory setae; tibiae I-II, 15 tactiles, 7 attenuate sensory setae. Tactile setae of legs slightly reduced from numbers indicated in holotype description.

Holotype: Female, Clinton, Douglas Co., Kansas, May 5, 1955, D. S. Narayan, grass (Berlese funnel extraction).

Allotype: Male, 1 mile west of Monticello, Madison Co., Florida, April 7, 1957, W. T. Atyeo, leaf litter.

Paratypes: One female, same data as holotype; four females, same data as allotype; two females, O'Leno State Park, Florida, April 6, 1957, W. T. Atyeo, leaf litter; one male, 2 females collected at Dinuba, Tulare Co., California, by Francis M. Summers as follows: one male, March 12, 1945, garden soil; one female, March 17, 1945, mulch; one female, March 26, 1945, mulch.

Location of types: Holotype, allotype, and seven paratypes deposited in the Snow Entomological Museum; one paratype at each of the following: the United States National Museum, the South Australian Museum, and the British Museum (Natural History).

Remarks: The Florida and California paratypes are approximately 1800 μ in length, slightly smaller than the holotype. In each of these specimens, there is a reduction in the number of setae; the palpal tibiotarsus has eight to nine setae, the palpal basifemur has five to six setae, and the genital plates have seven to eight setae each. The tactile setae on the leg segments (except the trochanters) and the attenuate sensory setae on the genua and the tibiae of legs I and II vary slightly from the numbers indicated in the description of the holotype. This species is named *simplex* because of the lack of striking morphological characters. Drawings of leg II, palpus, and dorsal propodosoma of the holotype; leg I drawn frm the Kansas paratype.

Genus *Octobdellodes*, gen. nov.

Type: *Octobdellodes hurdi* sp. nov.

This new genus is closely related to *Bdellodes*, but has the lateral propodosomal setae present and six or seven pairs of ventral hypostomal setae. The chelicerae are normal and each has two setae. The movable digits are smooth and longer than the fixed digits. The posterior pseudostigmatic organs are unmodified and the posterior sensilla are longer than the median propodosomal setae. Legs II are shorter than legs I.

KEY TO SPECIES OF OCTOBDELLODES

1. Palpal genu with four setae; palpal genu and telofemur approximately equal in length ..... *hurdi* p. 408
   Palpal genu with seven setae; palpal genu twice as long as the telofemur ..... *infrequens* p. 410

Octobdellodes hurdi, sp. nov.

(Figs. 18, 45, 93, 94, 152)

This species is related to *Octobdellodes infrequens*, sp. nov., but has the palpal genu and telofemur approximately equal in length, rather than the genu twice as long as the telofemur.

Female: Color in life unknown. Body narrowly ovoid, weakly constricted; length including gnathosoma, 1380 μ. *Gnathosoma:* Length, 374 μ; palpus (fig. 45) with tibiotarsus extending beyond hypostome; measurements: I, 17 μ; II, 189 μ; III, 32 μ; IV, 34 μ; V, 195 μ; *des*, 133 μ; *ves* 128 μ. Chelicera (fig. 18) normal, nonstriated, 323 μ in length; chela smooth, fixed digit shorter than movable digit; setae as figured. Gnathosomal base striated, buccal cone nonstriated; *vh 2-6* in longitudinal series, *vh 1, 2* form transverse row on striated base, *vh 3* between palpal articulations, *vh 3-5* equidistant, *vh 6* median between apices of lateral lips and *vh 5;* dorsal hypostomal setae equal in length to *vh 2*. *Dorsal propodosoma* (fig. 152): Striae finely broken; lateral propodosomals nude, 70 μ in length; median propodosomals nude, 85 μ in length; eyes subequal, interval between eyes equal to three diameters of the larger, anterior pair; distance between anterior sensilla, 68 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 68 μ, approximately one third of first interspace; external humeral, 73 μ in length; sacrals in gently curving transverse row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel; anal setae wanting; two pairs of paranals; postanals wanting. *Genital region:* Each genital plate with 7 small, equal setae in linear arrangement; 4 pairs of paragenitals; genital discs small, ovipositor with 14 subapical, 6 postmedial setae. *Legs* (figs. 93, 94): Claws with 4 lateral rays each, minute rays wanting; measurements: tibia I, 94 μ; tarsus I, 188 μ; tibia II, 80 μ; tarsus II, 172 μ. Chaetotaxy: coxae I-IV, 6 tactile setae each; trochanters I-IV, 1, 2, 2, 2 tactile setae; basifemora I-IV, 9, 9, 6, 3 tactile setae; telofemora I-IV, 7, 7, 6, 5 tactiles; genu I, 5 tactiles, 5 attenuate sensory setae; genua II-IV, 3 tactiles, 2 attenuate sensory setae; tibia I, 7 tactiles,

3 attenuate sensory setae, 1 peg, trichoboth; tibia II, 7 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 8 tactiles, 1 attenuate sensory seta; tibia IV, 8 tactiles, trichoboth; tarsus I, 15 plumose ventrals in two rows, 7 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 capitate peg, *dt 1* solid, nude, *dt 2*, 3 solid, plumose; tarsus II, 15 plumose ventrals, 5 lateral and 1 dorsal seta, 1 attenuate and 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, 15 plumose ventrals, 6 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 15 plumose ventrals, 5 laterals, trichoboth, *dt 1* reduced to 1 solid, nude seta, *dt 2*, 3 solid, plumose.

Male: Identical to female except in genital region; each genital plate with 8 setae; amphioid sclerites with 3, 4, 1 setae each.

Holotype: Female, Point Barrow, Alaska, July 5, 1952, P. D. Hurd, Berlese intermediate.

Allotype: Male, same data as holotype.

Paratypes: Four males and nine females collected by P. D. Hurd, at Point Barrow, Alaska, in 1952; these include: three females with same data as holotype; two males, four females, June 26, dry tundra, above frost line, top of polygon (Berlese funnel extraction); two males, one female, June 26, ring sample, frost scar on ridge; one female, July 26, ridge plot.

Location of types: The holotype, allotype, and five paratypes are deposited in the Snow Entomological Museum. Two paratypes are deposited at the following: the South Australian Museum, the British Museum (Natural History), the United States National Museum, and the University of California.

Remarks: Total size is relatively uniform, the greatest variation occurs in the numbers of setae. The holotype has six tactile setae on the left coxa IV and nine setae on the right coxa. Genital setae in the males vary from eight to nine pairs, and in the females, from seven to eight pairs. Tactile setae on the leg segments vary from two more, to two less, than the numbers indicated in the description of the holotype. The proximal seta on the medial surface of the palpal basifemur is absent in a few specimens. The species is named for Dr. P. D. Hurd of the University of California, who collected the type series of this species. Drawings are of the holotype.

Octobdellodes infrequens, sp. nov.

(Figs. 19, 20, 46, 89, 90, 153)

This species is related to *O. hurdi,* sp. nov., but can be distinguished by the palpal genu which is two times longer than the telofemur and which has seven setae rather than the genu equal in length to the telofemur and with four setae.

Female: Color in life unknown. Body large, ovoid, weakly constricted; length, including gnathosoma, 2700 μ. *Gnathosoma:* Length, 629 μ; palpus (fig. 46) long, half of the genu and tibiotarsus extending beyond hypostome; measurements: I, 30 μ; II, 357 μ; III, 68 μ; IV, 156 μ; V, 335 μ; *des,* 323 μ; *ves,* 264 μ. Chelicera normal, nonstriated, 575 μ in length; fixed digit and movable digit with preapical tooth, fixed digit slightly shorter than opposing digit; cheliceral setae inserted as in figs. 19, 20. Gnathosomal base striated, buccal cone nonstriated; *vh 1, 2* form transverse row on hypostome base, *vh 2-5, 7* form longitudinal series, *vh 6* mesad, *vh 1* laterad; *vh 2-7* approximately equidistant; dorsal hypostomal setae about half the length of *vh 1. Dorsal propodosoma* (fig. 153): Striae finely broken; lateral propodosomals nude, 158 μ in length; median propodosomals nude, 145 μ in length; eyes separated by distance equal to 2 diameters of anterior pair; distance between anterior sensilla, 68 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 146 μ, approximately half of first interspace; external humeral, 155 μ in length; sacrals in gently curving transverse row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel; anal setae wanting; 2 pairs paranals; postanals removed laterad of termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 9 long, equal setae in linear arrangement, 5 pairs of paragenitals; genital discs equidistant, in middle portion of vestibule; ovipositor with 16 subapical, 6 postmedical setae. *Legs* (figs. 89, 90): Claws with 6-7 lateral rays, 1 row of minute rays each; measurements: tibia I, 187 μ; tarsus I, 377 μ; tibia II, 187 μ; tarsus II, 377 μ. Chaetotaxy: coxae I-IV, 5, 5, 6, 3 tactile setae; trochanters I-IV, 1, 2, 2, 2 tactile setae; basifemora I-IV, 14, 15, 10, 5 tactile setae; telofemora I-IV, 10, 9, 9, 7 tactile setae; genu I, 6 tactile setae, 5 attenuate sensory setae; genu II, 6 tactile setae, 4 attenuate sensory setae; genua III-IV, 6 tactile setae and 3 attenuate sensory setae each; tibia I, 11 tactiles, 4 attenuate sensory setae, 1 peg, trichoboth; tibia II, 11 tactiles, 3 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 14 tactiles, 1 attenuate sensory seta; tibia IV, 13 tactiles, trichoboth; tarsus I, 32 plumose ventral

setae arranged in 2 rows on proximal third, in four rows on distal two thirds, 10 lateral and 2 dorsal tactiles, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus II, 32 plumose ventrals arranged as in tarsus I, 10 lateral and 2 dorsal tactiles, 1 attenuate and 2 blunt sensory setae, 1 peg, dorsoterminals as in tarsus I; tarsus III, ventrals, laterals, dorsoterminals as in tarsus II, trichoboth; tarsus IV, 36 ventrals, 8 laterals arranged as in tarsus I, trichoboth, *dt 1* reduced to 1 solid, nude seta, *dt 2, 3* solid, plumose.

Male: Identical to female except in size and chaetotaxy of the palpus. Measurements: length, including gnathosoma, 1740 μ; palpus: I, 26 μ; II, 325 μ; III, 54 μ; IV, 104 μ; V, 269 μ; *des*, 247 μ; *ves*, 207 μ; chelicera, 497 μ; gnathosoma, 476 μ; tibia I, 143 μ; tarsus I, 320 μ; tibia II, 143 μ; tarsus II, 317 μ. Setae on the dorsal propodosoma and dorsal hysterosoma only slightly shorter. Second palpal segment with 10 tactile setae, fifth segment with 12 tactile setae (excluding apical setae). Amphioid sclerites with 3, 4, 2 setae each.

Holotype: Male, Douglas County, Kansas, February 17, 1952, C. C. Hall, on shagbark hickory.

Allotype: Female, Sioux City, Iowa, October 15, 1921, C. N. Ainslie, under stone.

Paratypes: Male, Imoden, Arkansas, received at USNM January 14, 1935, from B. C. Marshall; female, Patuxent Wildlife Refuge, Maryland, January 13, 1954, R. O. Drummond, *Peromyscus leucopus noveboracensis* nest, no. 11.

Location of types: The holotype and paratypes are deposited in the Snow Entomological Museum; the allotype is deposited at the United States National Museum.

Remarks: It is difficult to estimate the amount of variation in the species because of the limited number of specimens. The allotype is an extremely large female, probably gravid, while the paratypes are comparable in size to the holotype. The number of ventral hypostomal setae in the four specimens is very variable. Five pairs of setae are always present on the buccal cone, but in the transverse row across the gnathosomal base, there may be two to three pairs, totaling therefore, seven to eight pairs of ventral hypostomal setae rather than the usual six pairs.

This species, although apparently widely distributed, has been infrequently collected, therefore the specific name of *infrequens* has been selected for this new taxon. Drawings of the holotype.

Genus *Bdellodes* Oudemans

Bdellodes Oudemans, 1937 (= *Scirus, sensu* Thor, 1931, *non* Hermann, 1804), Kritisch Historisch Overzicht der Acarologie, Leiden, vol. 3, part C, p. 1217. (Type: *Scirus longirostris* Hermann, 1804 [by original designation].)
Hoploscirus Thor, 1937, Zool. Anz., vol. 119, no. ½, p. 43 (new synonym). (Type: *Scirus dubitatus* Womersley, 1933 [by original designation].)

Bdellodes is closely related to *Octobdellodes,* gen. nov., but lacks the lateral propodosomal setae. The chelicerae are normal and each has one or two setae. The sickle-shaped movable digits are longer than the fixed digits, and may be smooth, flattened distally on the inner surfaces, or have a single tooth. The posterior pseudostigmatic organs are unmodified and the posterior sensilla are longer than the median propodosomal setae. Legs II are usually shorter than legs I.

The genus *Hoploscirus* was erected for species of *Bdellodes* (= *Scirus, sensu* Thor) with distinct, reniform dorsal shields. The differentiating character for this group is an extreme modification of cuticular deposition, which is considered to be a continuous character.

KEY TO THE SPECIES OF BDELLODES

1. Chelicera with one seta; palpal basifemur and tibiotarsus (excluding end setae) with twelve to fourteen setae each *longirostris* p. 412
   Chelicera with two setae; palpal basifemur and tibiotarsus (excluding end setae) with five to six setae each *bisetosa* p. 414

Bdellodes longirostris (Hermann)

(Figs. 14, 42, 87, 88)

Scirus longirostris Hermann, 1804, Mém. Apt. p. 62.
Bdella peregrina Banks var. *iowaensis* Ewing, 1917, Bull. Amer. Mus. Nat. Hist., vol. 37, p. 150 (new synonym).

This species is closely related to *Bdellodes porrectus* (Kramer) 1898, but the palpal genu and telofemur are approximately equal in length and each digit of the chela has one preapical tooth, rather than the genu twice as long as the telofemur and the digits smooth.

Female: Color in life red, with dark blue flecks. Body ovoid; length, including gnathosoma, 1810 μ (1335-2270 μ). *Gnathosoma:* Length, 504 μ (447-568 μ); palpus (fig. 42) with short, subequal end setae; measurements: I, 27 μ (24-28 μ); II, 357 μ (264-408 μ); III, 61 μ (60-63 μ); IV, 70 μ (50-70 μ); V, 325 μ (243-352 μ); *des,* 218 μ (197-238 μ); *ves,* 201 μ (179-201 μ). Chelicera (fig. 14) normal, nonstriated, 471 μ (412-547 μ) in length; each digit with one preapical tooth; single seta inserted at approximately two thirds of the length of chelicera from base. Gnathosomal base striated,

buccal cone nonstriated; *vh 2-6* form 2 longitudinal series, *vh 1* laterad, between articulations of palpi; *vh 2-5* approximately equidistant, *vh 6* median between *vh 5* and termination of buccal cone; dorsal hypostomal setae approximately equal in length to *vh 3*. *Dorsal propodosoma:* Striae finely broken, pattern similar to fig. 153; median propodosomals finely plumose, 133 μ (119-163 μ) in length; eyes separated by distance equal to 2 diameters of anterior pair, interval between eyes with transverse striae; distance between anterior sensilla, 85 μ (65-88 μ). *Dorsal hysterosoma:* Setae finely plumose; length of internal humeral, 99 μ (87-109 μ), approximately half of first interspace; external humeral, 100 μ (95-128 μ) in length; sacrals in gently curving transverse row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel; 1 pair of anal setae; paranals wanting; postanals flanking cleft approximately one fourth length of cleft from dorsal termination, shorter than clunals. *Genital region:* Each plate with 6 (7) long, equal, attenuate setae in linear arrangement; 4 (5) pairs of paragenitals, anterior pair at level of anterior termination of aperture; genital discs small, one pair at anterior end, two pairs approximate, caudad; ovipositor with 18 subapical setae. *Legs* (figs. 87, 88): Claws with 6-7 lateral rays and one row of minute rays each; measurements: tibia I, 167 μ (126-177 μ); tarsus I, 296 μ (264-325 μ); tibia II, 167 μ (126-175 μ); tarsus II, 296 μ (264-322 μ). Chaetotaxy: coxae I-IV, 5 (4), 3, 4, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 15 (13-16), 15 (14), 13 (9-13), 6 (4-6) tactile setae; telofemora I-IV, 8 (7), 7, 6, 6 (7) tactile setae; genu I, 6 (5) tactile setae, 5 (4-6) attenuate sensory setae; genu II, 6 tactile setae, 3 (2) attenuate sensory setae; genua III-IV, 6 (5) tactile setae and 2 attenuate sensory setae each; tibia I, 13 (10-14) tactile setae, 4 (3) attenuate sensory setae, 1 peg, trichoboth; tibia II, 12 (9-12) tactile setae, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 12 (11) tactile setae, 1 attenuate sensory seta; tibia IV, 13 (10-13) tactile setae, trichoboth; tarsus I, 29 (24-32) plumose ventral setae, distal members in 4 irregular rows, proximal members in 2 rows, 11 (10) lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus II, similar to tarsus I except with 9 (7-9) laterals, 1 dorsal tactile seta, 1 attenuate sensory seta; tarsus III, ventrals and dorsoterminals as in tarsus I, 8 laterals, trichoboth; tarsus IV, ventrals as in tarsus I, 9 laterals, trichoboth, *dt 1* reduced to one solid, nude seta, *dt 2, 3* solid, plumose.

Male: Identical to female; amphioid sclerites with 3, 4, 2 setae each.

Type: Europe.

Location of type: Unknown.

Remarks: Specimens examined were collected in: Mexico (Michoacán, Jalisco, Oaxaca, Guanajuato, México, Distrito Federal, Puebla, Nuevo León, Guerrero, Tamaulipas), the United States (Texas, California, Kansas, Arkansas, Florida, Michigan, Montana), Cuba, Costa Rica, Jamaica, Argentina, and Denmark. The number of setae on the palpus may vary from ten to fifteen on the basifemur, and from twelve to fourteen on the tibiotarsus. Redescription and drawings are based on two males from: twenty miles west of Morelia, Michoacán, Mexico, July 20, 1956, R. E. Beer, under rock.

Bdellodes bisetosa, sp. nov.

(Figs. 47, 91, 92, 155)

This species is related to *B. longirostris* but may be distinguished from this species by the chaetotaxy of the palpus, having five setae on the basifemur and tibiotarsus (excluding the end setae) rather than twelve to fourteen setae on each of these segments. In addition, *bisetosa* has two setae on each chelicera rather than one.

Female: Color unknown. Body narrowly ovoid, weakly constricted; length, including gnathosoma, 1100 μ. *Gnathosoma:* Length, 277 μ; palpus (fig. 47) short, distal half of the tibiotarsus extending beyond hypostome; measurements: I, 14 μ; II, 114 μ; III, 25 μ; IV, 39 μ; V, 124 μ; *des,* 119 μ; *ves,* 102 μ. Chelicera normal, nonstriated, 255 μ in length; movable digit with inner surface flattened distally, fixed digit with preapical tooth and shorter than movable digit; setae inserted as in *Bdella longicornis.* Gnathosomal base striated, buccal cone nonstriated; *vh 1-5* equidistant, in longitudinal series, *vh 6* medial between apex and *vh 5, vh 1* inserted between palpal articulations; dorsal hypostomal setae approximately half the length of *vh 1. Dorsal propodosoma* (fig. 155): Striae finely broken; median propodosomals nude, 70 μ in length; eyes separated by distance equal to three diameters of anterior pair; distance between anterior sensilla, 60 μ. *Dorsal hysterosoma:* Setae nude, length of internal humeral, 51 μ, approximately one half of first interspace; external humeral, nude, 50 μ in length; sacrals in gently curving transverse row, clunals in subrectangular arrangement. *Anal region:* Border striae parallel; anal setae wanting; one pair of paranals; postanals flanking termination of cleft, approximately equal

in length to external clunals. *Genital region:* Each genital plate with 9 small, equal setae in linear arrangement; 3 pairs of paragenitals; genital discs small, equidistant; ovipositor with 16 subapical, 4 postmedial setae. *Legs* (figs. 91, 92): Claws with 5 to 6 lateral rays each, distally alternating with 4 short rays; measurements: tibia I, 70 μ; tarsus I, 170 μ; tibia II, 77 μ; tarsus II, 170 μ. Chaetotaxy: coxae I-IV, 6, 3, 6, 2 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 10, 10, 9, 4 tactile setae; telofemur I, 7 tactile setae, 1 attenuate sensory seta; telofemora II-IV, 7 tactile setae each; genu I, 5 tactiles, 6 attenuate sensory setae; genu II, 4 tactiles, 4 attenuate sensory setae; genu III, 5 tactiles, 3 attenuate sensory setae; genu IV, 5 tactiles, 3 attenuate sensory setae; tibia I, 8 tactiles, 3 attenuate sensory setae, 1 hollow peg, trichoboth; tibia II, 8 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia III, 10 tactiles, 1 attenuate sensory seta; tibia IV, 9 tactiles, trichoboth; tarsus I, 13 plumose ventrals arranged in 2 rows, 5 lateral and 2 dorsal tactile setae, 2 attenuate and 2 blunt sensory setae, 1 peg, dorsoterminals solid, plumose; tarsus II, 14 ventrals as in tarsus I, 5 lateral and 2 dorsal tactile setae, 2 blunt sensory setae, 1 peg, dorsoterminals solid, plumose; tibia III, ventrals, laterals, and dorsoterminals as in tarsus I, trichoboth; tarsus IV, 14 ventrals as in tarsus I, 5 laterals, trichoboth, *dt 1* reduced to 1 solid, plumose seta, *dt 2, 3* solid, plumose.

Male: Identical to female except in general size and genital region; length including gnathosoma, 995 μ; genital plates with 8 pairs of setae; amphioid sclerites with 1, 6, 1 setae each.

Holotype: Female, 10 miles west of Tuxtla Gutierrez, Chiapas, Mexico, July 8, 1955, R. E. Beer, under rock.

Allotype: Male, same data as holotype.

Paratypes: Six males and six females, same data as holotype; one male, one female, 17 miles north of Tehuitzingo, Puebla, Mexico, July 18, 1955, R. E. Beer, under rocks.

Location of types: The holotype, allotype, and eight paratypes deposited in the Snow Entomological Museum; two paratypes deposited in each of the following: the United States National Museum, the South Australian Museum, and the British Museum (Natural History).

Remarks: The number of pairs of setae on the female genital plates may be eight, nine, or eleven. When the latter number occurs, two setae are lateral to the longitudinal series. The amphioid sclerites of the male have one or two setae in the anterior

group plus six median setae and one posterior seta. Variation in general size is slight in the small type series. Because of the two setae on each chelicera, rather than the usual number of one, this new species is named *bisetosa.* Drawings of the holotype.

Cytinae Grandjean, 1938

The members of this subfamily have two pairs of conspicuous ventral hypostomal setae, maximally three pairs of trichoboths, and well developed genital tracheae. The palpal tibiotarsus is truncate and usually slightly longer than the combined length of the genu and telofemur. The subequal end setae are longer than the palpal femur. The chelicerae are thickened (*Cyta*) or normal (*Trachymolgus*) and each bears two setae, one of which is inserted at the base of the fixed digit. The dorsal propodosoma has lateral propodosomal setae, secondary apodemes well develoed, four eyes lateral to the unmodified posterior pseudostigmatic organs, and in *Cyta,* a fifth, unpaired eye between the anterior sensilla. The podocephalic canal is an internal tube in *Trachymolgus* and an external groove in *Cyta* (Grandjean, 1938). An unpaired seta occurs immediately anterior to the genital flaps (between coxae IV in *Cyta spuria,* sp. nov).

Genus *Cyta* von Heyden

Cyta v. Heyden, 1826, Isis von [Lorenz von] Oken, Leipzig (= Encyklopädische Zeitsch. vorz. Naturgesch., vergl. Anat. und Phys., vol. 19, no. 6, p. 608. (Type: *Scirus latirostris* Hermann,, 1804 [by original designation].)

Amonia Koch, 1836, Deutschlands Crustaceen, Myriapoden und Arachniden. Ein Beitrag zur Deutschen Fauna von C. L. Koch, Regensburg, fasc. 5, no. 7. (Type: *Amonia cruciata* Koch, 1836 [= *Cyta latirostris* Hermann] [first included species].)

Ammonia Koch, 1842 (*non* Bruennich, 1772, Mollusca), Übersicht des Arachnidensystems von C. L. Koch, Nürnberg, vol. 3, p. 75. (Type: *Amonia megacephala* Koch, 1839 [= *Cyta latirostris* Hermann] [by original designation].)

Troglobdella Oudemans, 1937, Kritisch Historisch Overzicht der Acarologie, Leiden, vol. 3, part C, p. 1228 (new synonym). (Type: *Scirus obisium* Gervais, 1841 [= *Cyta latirostris* Hermann] [by original designation].)

The genus *Cyta* is related to *Trachymolgus,* but is distinguished by thickened chelicerae with massive chelae, and an unpaired median eye between the anterior sensilla. The distal pair of ventral hypostomal setae are inserted immediately anterior or posterior to the suture separating the buccal cone and the strongly developed lateral lips. The posterior sensilla are widely separated and near the lateral margins of the dorsal propodosoma. Well developed lateral apodemes and weakly developed transverse apodemes are present. There may be three, one, or no pairs of trichoboths. The podocephalic canal is an external groove (Grandjean, 1938).

Troglobdella Oudemans is tentatively placed in synonymy with *Cyta*. Oudemans erected this genus for a poorly described and poorly illustrated species, *Scirus obisium* Gervais, 1841. As described by Gervais, this species lacks both trichoboths and eyes, has extremely short palpi and end setae, is light orange to translucent in color, and has the posterior pseudostigmatic organs widely separated. Except for the apparent lack of eyes, the other distinguishing features of *Scirus obisium* can be found in a proto- or deutonymph of *Cyta latirostris*. It is possible to imagine that eyes could be overlooked because of poor optical equipment or an unsatisfactory method of preparation.

Key to Cyta

1. Trichoboths on tibiae I, IV, tarsus III; lateral propodosomals not approximate to posterior sensilla 2
   Trichoboth on tibia IV; lateral propodosomals approximate to posterior sensilla ..... *latirostris* p. 417
2. Integument purple; palpal basifemur with more than six setae and extending well beyond hypostome ..... *coerulipes* p. 419
   Integument not purple; palpal basifemur with less than six setae and not extending well beyond hypostome ..... *spuria* p. 421

Cyta latirostris (Hermann)

(Figs. 30, 60, 164, 172, 178)

Scirus latirostris Hermann, 1804, Mém. Apt., p. 62.
Bdella robustirostris Ewing, 1913, Bull. Amer. Mus. Nat. Hist., vol. 32, p. 112, plate 7, fig. 3.
Cyta novangliae Jacot, 1939, Occ. Pap. Boston Soc. Nat. Hist., vol. 8, p. 322 (not examined) (new synonym).

This species is related to *Cyta spuria*, sp. nov., but has only one pair of trichoboths inserted on tibia IV, rather than three pairs inserted on tibiae I and IV and tarsi III.

Female: Color in life dark red with dark blue-black blotches. Body short, robust; length, including gnathosoma, 925 μ (664-1100 μ). *Gnathosoma:* Length, 178 μ (160-221 μ); palpus (fig. 60) with basifemur not extending beyond hypostome; measurements: I, 17 μ (16-20 μ); II, 124 μ (107-126 μ); III, 29 μ (24-34 μ); IV, 27 μ (24-34 μ); V, 66 μ (53-68 μ); *des*, 170 μ (136-196 μ); *ves*, 131 μ (111-160 μ). Chelicera (fig. 30) inflated, thickened distally, striated, 173 μ (153-209 μ) in length; inner surface of fixed digit with 2 distal teeth; setae as figured. Gnathosoma striated; *vh 2* inserted on lateral lips, immediately anterior to articulation of lips; dorsal hypostomals longer than *vh 2*. *Dorsal propodosoma* (fig. 164): Striae finely broken; lateral propodosomals nude, approxi-

mately 54 μ (54-80 μ) in length; median propodosomals minutely pilose, 44 μ (41-71 μ) in length; eyes separated by distance equal to two and one-half diameters of anterior pair; distance between anterior sensilla, 110 μ (102-155 μ). *Dorsal hysterosoma:* Setae minutely pilose to pilose; length of internal humeral, 44 μ (36-60 μ), approximately one third to one half of first interspace; external humeral, 41 μ (37-60 μ) in length; sacrals and clunals in gently curving transverse rows. *Anal region:* Border striae parallel; 2 pairs of anal setae; 3 pairs of paranals; postanals wanting. *Genital region:* Each genital plate with 8 (7-9) unequal setae in irregular linear arrangement, anterior 3 setae longer than posterior 6 (5-7) setae; 6 pairs of paragenital setae, 1 unpaired median seta anterior to genital plates; genital discs small, equidistant, in central region of vestibule; ovipositor with 18 subapical, 2 postmedial setae. *Legs* (similar to figs. 113, 114): Claws with one row of minute rays each, lateral rays wanting; measurements: tibia I, 99 μ (83-119 μ); tarsus I, 124 μ (107-126 μ); tibia II, 61 μ (51-68 μ); tarsus II, 85 μ (75-112 μ). Chaetotaxy: coxae I-IV, 5, 5 (4), 4, 2 tactile setae; trochanters I-IV, 2 (1), 2, 2, 2 (3) tactile setae; basifemora I-IV, 9 (10), 8 (9), 7, 4 tactile setae; telofemora I-IV, 5 (5-7), 6 (7), 4 (4-6), 4 (4-6) tactile setae; genua I-III, 7 (6) tactile setae and 1 attenuate sensory seta each; genu IV, 6 tactile setae; tibia I, 9 (8) tactiles, 1 attenuate and 1 blunt sensory seta, 1 peg; tibia II, 9 (8) tactiles, 1 large and 1 small blunt sensory seta; tibia III, 9 (8) tactiles, 1 blunt sensory seta; tibia IV, 8 (7) tactiles, trichoboth; tarsus I, 14 (11-14) minutely pilose ventral setae arranged in 2 rows, 8 lateral and 2 dorsal tactiles, 2 (1) attenuate and 2 blunt sensory setae, 1 peg, *dt 1, 3* hollow, minutely pilose, *dt 2* solid, nude; tarsus II, 11 (11-12) ventrals, 6 lateral and 2 dorsal tactiles, 1 blunt sensory seta, 1 peg, *dt 1,* anterior *dt 3* as in tarsus I, *dt 2,* posterior *dt 3* solid, minutely pilose; tarsus III, 12 (10-13) ventrals, 6 (5) lateral and 1 dorsal tactile seta, dorsoterminals solid, minutely pilose; tarsus IV, 13 (10-13) ventrals, 1 attenuate sensory seta, *dt 1* reduced to one solid, minutely pilose seta, *dt 2, 3* as in tarsus III.

Male: Identical to female; amphioid sclerites as in fig. 172.

Type: Europe.

Location of type: Unknown.

Remarks: Approximately one hundred specimens were examined, which included material from: Cuba, Jamaica, Mexico (Puebla, México, San Luis Potosí), the United States (California, Utah, Idaho, Texas, Arkansas, Kansas, Nebraska, North Dakota, Michigan,

Alabama, Tennessee, West Virginia, Maryland, Connecticut), Alaska (Point Barrow), Iceland, Italy, Germany, and Australia.

Two specimens from Italy have three setae on the palpal genu, which agrees with Thor's (1931) description of this species, the remainder of the specimens have four setae on this segment. The number of tactile setae on the appendages varies only slightly from the numbers indicated in the above description, although there may be four to seven setae on the palpal basifemur. Special sensory setae are constant, except for the occasional absence of one attenuate sensory seta on tarsus I. Grandjean (1938) reports that *C. latirostris* in Europe is actually composed of two species; the typical species with one pair of trichoboths and another species lacking trichoboths. Only individuals of the first type were encountered in the present study. The description and illustrations are based on a female from: near Sheep Canyon, Borego State Park, San Diego Co., California, April 27, 1955, R. O. Schuster, sycamore and palm litter.

Cyta coerulipes (Dugès)

(Figs. 31, 57, 58, 115, 116, 165, 171)

Type: *Bdella coerulipes* Dugès, 1834, Ann. Sci. Nat., ser. 2, vol. 2, p. 45.

This distinctive species is related to *C. spuria,* sp. nov., but is easily distinguished by having a purple integument, the palpal basifemur extending beyond the hypostome, and external sacrals and clunals longer than the same internal members. In contrast, *C. spuria* has a neutral colored integument, the palpal basifemur is shorter than the hypostome, and the sacrals and clunals are of approximately equal lengths.

Female: Color in life dark yellow with brown blotches to deep purple. Body strongly widened at shoulders; length including gnathosoma, 860 μ (750-1100 μ). *Gnathosoma:* Length, 254 μ (214-266 μ); palpus (figs. 57, 58) with elongate basifemur extending slightly beyond hypostome; measurements: I, 19 μ (17-20 μ); II, 250 μ (179-277 μ); III, 34 μ (26-36 μ); IV, 32 μ (24-34 μ); V, 94 μ (71-95 μ); *des,* 316 μ (292-316 μ); *ves,* 240 μ (211-240 μ). Chelicera (fig. 31) thickened distally, faintly striated, 226 μ (192-238 μ) in length; fixed digit with broad tooth medially; setae as figured. Gnathosomal base and proximal two thirds of buccal cone striated; *vh 2* inserted immediately proximal to lateral lips; dorsal hypostomals approximately equal in length to adornal setae. *Dorsal propodosoma* (fig. 165): Striae sparsely broken; lateral propodosomals

plumose, 92 μ (66-111 μ) in length; median propodosomals plumose, 129 μ (111-167 μ) in length; eyes separated by distance equal to two and one half diameters of anterior pair; distance between anterior sensilla, 112 μ (85-117 μ). *Dorsal hysterosoma:* Setae plumose; length of internal humeral, 114 μ (105-145 μ), approximately equal to first interspace; external humeral, 122 μ (85-170 μ) in length; sacrals and clunals in strongly curving transverse rows. *Anal region:* Border striae parallel; anal and postanal setae wanting; 3 (2) pairs of paranals. *Genital region:* Each genital plate with 9 unequal setae in linear arrangement, anterior 3 longer than posterior 6; 6 (7) pairs of paragenitals; unpaired median seta caudad to coxae IV; ovipositor with 18 subapical, 2 postmedial setae. *Legs* (figs. 115, 116): Claws with one row of minute rays each, lateral rays wanting; measurements: tibia I, 95 μ (78-107 μ); tarsus I, 153 μ (128-160 μ); tibia II, 83 μ (60-95 μ); tarsus II, 136 μ (119-146 μ). Chaetotaxy: coxae I-IV, 5 (4), 4 (5), 5 (6), 4 (3-5) tactile setae; trochanters I-IV, 2 tactile setae each; basifemora I-IV, 7 (8), 7 (5-8), 7 (6-8), 5 (4) tactile setae; telofemora I-IV, 5 (5-7), 5 (4-6), 4 (5), 4 (3) tactile setae; genu I, 4 (3) tactiles, 2 attenuate sensory setae; genu II, 4 (5) tactiles, 1 attenuate sensory seta; genu III, 5 (4-6) tactiles, 1 attenuate sensory seta; genu IV, 6 (5) tactiles, 1 attenuate sensory seta; tibia I, 8 (8-10) tactiles, 2 attenuate sensory setae, 1 peg, trichoboth; tibia II, 9 (8) tactiles, 1 attenuate and 1 blunt sensory seta; tibia III, 9 (8-10) tactiles, 1 attenuate sensory seta; tibia IV, 10 (9) tactiles, trichoboth; tarsus I, 12 (11-13) pilose ventrals arranged in two rows, 8 (7) lateral and 2 dorsal tactiles, 2 (1) attenuate and 2 blunt sensory setae, dorsoterminals solid, pilose; tarsus II, 10 (11) ventrals, 7 (8) lateral and 2 dorsal tactiles, 1 attenuate and 1 blunt sensory seta, dorsoterminals as in tarsus I; tarsus III, 12 ventrals, 8 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 12 (11) ventrals, 6 laterals, 1 attenuate sensory seta, tricohboth wanting, *dt 1* reduced to one solid, pilose seta, *dt 2, 3* solid, pilose.

Male: Identical to female; amphioid sclerites each with 9 (8) setae (fig. 171).

Type: Europe.

Location of type: Unknown.

Remarks: Approximately 200 slides were examined, which included specimens from: Panama, Haiti, Cuba, Mexico (San Luis Potosí, Guerrero, Tamaulipas, Hidalgo), the United States (Colorado, California, Texas), Alaska (Umiat) and Sudan Bor.

Slight, but constant variation in the widely separated localities indicates that *C. coerulipes* may be a group of closely related species or subspecies. Extreme variation is found in the forms of the palpal setae. In southeastern Texas and northeastern Mexico, the small tactile setae are strongly plumed (fig. 58), a condition not found in other geographical areas. The attenuate sensory setae on tibia I undergo considerable migration and reduction in numbers, for example, the Cuban specimens have the two approximate attenuate sensory setae near the distal margin of the segment rather than the proximal margin (fig. 115). Specimens from Panama have three sensory setae in a linear arrangement, while those from Colorado and Sudan Bor have only two attenuate sensory setae.

The striae on the dorsal propodosoma are usually almost continuous, but in the insular material, the striae are finely broken, resembling those found in *Cyta latirostris* (fig. 164).

The redescriptions and illustrations are based on a male and a female from: five miles east of Ciudad del Maiz, San Luis Potosí, Mexico, August 23, 1954, W. T. Atyeo, ground litter, altitude 4,700 feet. An illustration of plumose setae on the palpus was prepared from a male from: ten miles north of Edinburg, Texas, April 9, 1954, R. E. Beer, under rock.

Cyta spuria, sp. nov.

(Figs. 11, 59, 113, 114, 167, 173)

In size and shape, this species closely resembles *Cyta latirostris*, but may be distinguished by the presence of trichoboths on tibiae I, IV, and tarsus III rather than trichoboths only on tibia IV.

Female: Color in life unknown. Body short, robust, weakly constricted; length, including gnathosoma, 810 μ. *Gnathosoma:* Length, 194 μ; palpus (fig. 59) with basifemur-telofemur articulation indistinct; measurements: I, 14 μ; II plus III, 138 μ; IV, 22 μ; V, 61 μ; *des*, 179 μ: *ves*, 136 μ. Chelicera inflated, striated, 158 μ in length; fixed digit smooth, longer than movable digit (fig. 11); distal seta inserted above proximal limit of movable digit, proximal seta as in *C. latirostris*, except extending beyond articulation of chela. Gnathosomal base and proximal two thirds of buccal cone striated; *vh 2* immediately proximal to lateral lips; dorsal hypostomal setae equal in length to *vh 2*. *Dorsal propodosoma* (fig. 167): Striae very finely broken; lateral propodosomals plumose, 77 μ in length; median propodosomals plumose, 78 μ in length; eyes separated by distance equal to two and one half diameters of anterior pair; distance between anterior sensilla, 97 μ. *Dorsal hysterosoma:*

Setae plumose; length of internal humeral, 73 μ, approximately three fourths of first interspace; external humeral, 77 μ in length; sacrals and clunals in strongly curving transverse rows. *Anal region:* Border striae parallel; anal and postanal setae wanting; 3 pairs of paranals. *Genital region:* Each genital plate with 9 unequal setae in linear arrangement, anterior 3 longer than posterior 6; 9 pairs of paragenitals; 1 median unpaired seta between coxae IV; ovipositor with 20 setae of undeterminable position. *Legs* (figs. 113, 114): Claws with row of minute rays each, lateral rays wanting; measurements: tibia I, 73 μ; tarsus I, 128 μ; tibia II, 68 μ; tarsus II, 133 μ. Chaetotaxy: coxae I-IV, 5 (of which 1 longer than femur II), 1, 5, 2 tactile setae; trochanters I-IV, 2, 2, 2, 1 tactile setae; basifemora I-IV, 8, 8, 7, 5 tactile setae; telofemora I-IV, 5, 5, 4, 4 tactile setae; genua I-IV, each with 4 tactile setae and duplex seta with microseta in form of short, hollow peg; tibia I, 8 tactiles, 2 attenuate sensory setae, 1 peg, trichoboth; tibia II, 8 tactiles, 1 attenuate and 1 blunt sensory seta; tibia III, 8 tactiles, 1 attenuate sensory seta; tibia IV, 9 tactiles, trichoboth; tarsus I, 12 minutely pilose ventrals in 2 rows, 8 lateral and 2 dorsal tactile setae, 1 attenuate and 2 blunt sensory setae, dorsoterminals solid, minutely pilose; tarsus II, similar to tarsus I, except lacking 1 attenuate and 1 blunt sensory seta; tarsus III, ventrals, laterals and dorsoterminals as in tarsus I, trichoboth; tarsus IV, ventrals and dorsoterminals as in tarsus I, 6 lateral tactile setae, 1 attenuate sensory seta.

Male: Identical to female, except slightly smaller in general size; total length, 710 μ; amphioid sclerites as in fig. 173.

Holotype: Male, 10 miles east of Xilitla, San Luis Potosí, Mexico, July 25, 1954, Warren T. Atyeo, beating bamboo.

Allotype: Female, same data as holotype.

Paratypes: Six males, nine females, same data as holotype; one male, one female, 12 miles east of Xilitla, San Luis Potosí, Mexico, June 20, 1955, R. E. Beer, on bamboo; one male, 10 miles east of Tuxtla Gutierrez, Chiapas, Mexico, July 8, 1955, R. E. Beer, under rock; one female, Huatusco, Veracruz, Mexico, at Brownsville, Texas, August 22, 1949, with orchid plants.

Location of type: The holotype, allotype, and thirteen paratypes deposited at the Snow Entomological Museum; two paratypes deposited at each of the following: the United States National Museum, the British Museum (Natural History), and the South Australian Museum.

Remarks: The proximal setae on the appendages tend to be minutely pilose while the distal setae tend to be pilose. Except for the slight variation in the number of tactile setae on the leg segments, the other features of this species are very stable. Total length, including gnathosoma, approximately 699 μ to 800 μ. Drawings of the holotype.

Genus *Trachymolgus* Berlese

Trachymolgus Berlese, 1923, Redia, vol. 15, p. 242. (Type: *Bdella nigerrima* Canestrini and Fanzago, 1876 [by original designation].)

Although related to *Cyta,* this European genus has two unique features. The integument of the idiosoma is heavily sclerotized and reticulated, and instead of round genital tracheae, this group is characterized by platytracheae which expand near their terminations over coxae II (Grandjean, 1938). The chelicerae are normal and the small chelae are dentate. The cheliceral setae are arranged as in *Cyta,* that is, the distal seta is inserted at the base of the fixed digit. The palpal tibiotarsus is not strongly shortened nor widened distally, but elongated as in *Biscirus* and *Monotrichobdella.* Two pairs of widely separated eyes and four pairs of setae occur on the dorsal propodosoma; the podocephalic canal is an internal tube (Grandjean, 1938). Three pairs of trichoboths are inserted on the legs. Specimens of this genus were not available for examination.

Spinibdellinae Grandjean, 1938

The Spinibdellinae is distinguished by two pairs of conspicuous ventral hypostomal setae, four pairs of trichoboths, and well developed genital tracheae. The palpal tibiotarsus is truncate and shorter than the combined length of the genu and telofemur in *Spinibdella* or cylindrical and longer than the combined segments in *Biscirus* and *Monotrichobdella.* The subequal end setae are as long, or longer than the palpal femur. Elongated chelicerae bear two setae inserted on the distal two thirds and small, needlelike chelae. The dorsal propodosoma with or without lateral propodosomal setae; secondary apodemes absent or poorly developed; two or four eyes lateral to the unmodified posterior pseudostigmatic organs; and the propocephalic canal is an internal tube (Grandjean, 1938). If present, unpaired setae on the venter of the hysterosoma are between the coxae, not immediately anterior to the genital flaps.

The three genera comprising this subfamily are similar. They are separated primarily by the shape of the palpal tibiotarsus, the number of end setae, and the presence or absence of the lateral propodosomal setae.

Genus *Spinibdella* Sig Thor

Spinibdella Thor, 1930, Zool. Anz., vol. 92, no. 1, p. 22. (Type: *Spinibdella reducta* Thor, 1930 [by original designation].)

Spinibdella is closely related to *Biscirus,* but has a short and truncated palpal tibiotarsus, and the lateral propodosomal setae are present. The palpal genu has three or four setae, and the basifemur has more than two setae. The cheliceral setae may be minute or of medium length, with the distal seta not extending beyond the tips of the chelae. Striation patterns on the dorsum of the propodosoma appear to be specific as do the modified setae on the amphioid sclerites of the males.

KEY TO THE SPECIES OF SPINIBDELLA

1. Palpus much shorter than the hypostome; cheliceral setae minute ..... *tenuirostris* p. 424
   Palpus longer than hypostome; cheliceral setae conspicuous 2
2. Palpal tibiotarsus approximately the same length and diameter of palpal genu ..... *corticis* p. 426
   Palpal tibiotarsus longer and thicker than the genu 3
3. Blunt sensory seta on tibia II deeply recessed 4
   Blunt sensory seta on tibia II not recessed 5
4. One pair of eyes; internal humerals half of first interspaces *depressa* p. 428
   Two pairs of eyes; internal humerals equal to first interspaces *bifurcata* p. 430
5. Internal humerals equal to first interspaces; tibia II with one blunt sensory seta ..... *cronini* p. 432
   Internal humerals half of first interspaces; tibia II with one blunt and one attenuate sensory seta ..... *ornata* p. 434

Spinibdella tenuirostris (Ewing), new combination

(Figs. 32, 61, 123, 124, 157)

Bdella tenuirostris Ewing, 1914, Bull. Amer. Mus. Nat. Hist., vol. 37, p. 149.
Spinibdella wilsoni Jacot, 1938, Psyche, vol. 45, no. 2-3, pp. 129-130 (new synonym).

This species is closely related to, or conspecific with *Spinibdella reducta* Thor, 1930, and possibly *Spinibdella lignicola* (Berlese), 1892 (= *Bdella lignicola* Berlese), but the inadequate descriptions make it impossible to determine the true synonymies of this species. Both *tenuirostris* and *reducta* have the gnathosoma considerably longer than the palpus, and both have minute cheliceral setae. Berlese's species with "*setis mandibularum deficientibus vel minimis, palpisque cortioribus*" can not be evaluated with certainty.

Female: Color unknown. Body pear-shaped, weakly constricted; length, including gnathosoma, 1100 μ. *Gnathosoma:* Length, 330 μ;

palpus (fig. 61) considerably shorter than hypostome; measurements: I, 15 μ; II plus III, 153 μ; IV, 20 μ; V, 54 μ; *des,* 185 μ; *ves,* 160 μ. Chelicera nonstriated, 306 μ in length; setae small, each 9 μ in length, inserted on distal half of chelicera (fig. 32). Gnathosoma striated proximal to ventral setae; dorsal hypostomal setae wanting. *Dorsal propodosoma* (fig. 157): Striae coarsely broken; lateral propodosomals nude, 46 μ in length; median propodosomals nude, 60 μ in length; eyes subequal, separated by distance equal to 2 diameters of smaller, posterior pair, interval between eyes with transverse striae; distance between anterior sensilla, 90 μ. *Dorsal hysterosoma:* Setae nude; length of internal humeral, 83 μ, approximately three fourths of first interspace; external humeral, 83 μ in length; sacrals and clunals in gently curving transverse rows. *Anal region:* Border striae parallel; 3 pairs of anal setae; 3 pairs of paranals; postanals distant from termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 8 equal setae in linear arrangement; 10 pairs of paragenitals, anterior pair between coxae IV; ovipositor with 18 setae of interminable position. *Legs* (figs. 123, 124): Claws small, shorter than pretarsus, with 4-5 lateral rays; measurements: tibia I, 97 μ; tarsus I, 128 μ; tibia II, 78 μ; tarsus II, 119 μ. Chaetotaxy: coxae I-IV, 5, 5, 5, 3 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 11, 10, 9, 4 tactile setae; telofemora I-IV, 11, 10, 8, 6 tactile setae; genu I, 7 tactiles, 5 attenuate sensory setae, 1 small, solid seta; genu II, 7 tactiles and 1 attenuate sensory seta; genua III-IV, 7 tactiles, 1 attenuate sensory seta each; tibia I, 15 tactiles, 8 attenuate sensory setae, 1 attenuate peg, trichoboth; tibiae II-III, 13 tactiles, 1 attenuate and 1 blunt sensory seta; tibia IV, 12 tactiles, trichoboth; tarsus I, 14 plumose ventrals arranged in 2 rows, 9 lateral and 2 dorsal tactiles, 3 attenuate and 2 blunt sensory setae, 1 capitate peg, *dt 1* hollow, nude, *dt 2, 3* hollow; plumose; tarsus II, 12 plumose ventrals, 8 lateral and 2 dorsal tactile setae, 2 blunt sensory setae, 1 peg, *dt 1* solid, nude, *dt 2, 3* solid, plumose; tarsus III, 12 plumose ventrals, 9 laterals, trichoboth, dorsoterminals as in tarsus II; tarsus IV, 12 plumose ventrals, 7 laterals, trichoboth, attenuate sensory seta posterolateral of trichoboth, dorsoterminals as in tarsus II.

Male: Unknown.

Type: Female, *Bdella tenuirostris,* Xenia, Ohio, September 14, 1910, H. E. Ewing, under stones.

Location of type: The United States National Museum.

Remarks: Three female cotypes of *Spinibdella wilsoni* Jacot were examined; these were collected 7 miles from south point of North Beach, St. Augustine, Florida, March 7, 1928, E. F. Grossman, leaf litter of *Tamola littoralis* on shore bay. These cotypes are further identified by E. F. Grossman's code numbers: two females, G34Bd1 and one female, G34Bd3. In addition to the types, specimens were examined from Florida, Arkansas, Kansas, North Carolina, Vermont, Michigan, and California.

This is a highly variable species, and although subspeciation is probable, no correlations of characters can be made with the specimens available for study. Extensive variation occurs in the special sensory setae on tibia I, the chaetotaxy of the palpus, the number of setae in the genital region, and the general size. The California and Arkansas specimens have only one long attenuate sensory seta distal to the trichoboth on tibia I, whereas the specimens from other locales have two setae in this position. The proximal sensory setae of tibia I vary from five to six in number, and in the specimens from Florida, North Carolina, Arkansas and California, they are approximately one fourth the length of the tibia. In the Kansas specimens and the *wilsoni* cotypes, the same sensory setae are almost one half the tibial length.

Variation in the number of setae on the palpus is confined to the basifemur and genu. The Kansas specimens have five setae on the basifemur, while the remaining specimens have seven setae; the genua of individuals from Kansas, Michigan, and Florida (Jacot's cotypes) have four setae, the other specimens have only three. The genital setae vary from five to eight pairs, and there may be as many as two unpaired paragenital setae between the posterior coxae. Total length varies from 880 μ to 1420 μ. Drawings of Ewing's type.

Spinibdella corticis (Ewing), new combination

(Figs. 33, 66, 127, 128, 156)

Bdella corticis Ewing, 1909, Can. Ent., vol. 41, no. 4, p. 122.

Although related to *Spinibdella bifurcata*, sp. nov., this species is distinctive in having the palpal tibiotarsus approximately equal in length and diameter to the palpal genu. *S. bifurcata*, as well as the other known species of this genus, has the palpal tibiotarsus considerably larger than the genu.

Female: Color unknown. Body pear-shaped; length, including gnathosoma, 1243 μ. *Gnathosoma:* Length, 391 μ; palpus (fig. 66) with genu longer than tibiotarsus; measurements: I, 25 μ; II, 291 μ;

III, 33 μ; IV, 58 μ; V, 50 μ; *des,* 417 μ; *ves,* 349 μ. Chelicera (fig. 33) striated, 347 μ in length; setae as figured. Gnathosoma striated; dorsal hypostomal setae conspicuous, 48 μ in length. *Dorsal propodosoma* (fig. 156): Striae sparsely broken; lateral propodosomals with minute branchings, 84 μ in length; median propodosomals branched, 126 μ in length; eyes separated by distance equal to diameter of anterior pair, interval between eyes with longitudinal striae; distance between anterior sensilla, 68 μ. *Dorsal hysterosoma:* Setae branched; length of internal humeral, 118 μ, approximately the length of the first interspace; external humeral, 149 μ in length; sacrals in strongly curving transverse row, clunals in subtrapazoidal arrangement. *Anal region:* Border striae parallel, 2 pairs of anal setae; 1 pair of paranals; postanals flanking anal cleft, shorter than clunals. *Genital region:* Each genital plate with 10 long setae in linear arrangement; 28 pairs of paragenitals, anterior 4 pairs between coxae IV; median, unpaired setae wanting; genital discs small, distant; ovipositor short, with 14 pairs of subapical setae. *Legs* (figs. 127, 128): Claws small, shorter than pretarsus, each with one row of minute lateral rays; measurements: tibia I, 99 μ; tarsus I, 126 μ; tibia II, 99 μ; tarsus II, 137 μ. Chaetotaxy: coxae I-IV, 10, 8, 8, 7 tactile setae, many equal in length to basifemur I; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 13, 12, 7, 4 tactile setae; telofemora I-IV, 8, 9, 6, 6 tactile setae; genua I-III, 6 tactiles and 1 duplex seta each; genu IV, 6 tactiles; tibia I, 18 tactiles, 2 attenuate sensory setae, 1 peg, trichoboth; tibia II, 18 tactiles, 1 attenuate and 1 blunt sensory seta; tibia III, 15 tactiles, 1 attenuate sensory seta; tibia IV, 14 tactiles, trichoboth; tarsus I, 16 ventrals, 9 lateral and 2 dorsal tactiles, 1 attenuate and 2 blunt sensory setae, *dt 1, 3* hollow, nude, *dt 2* solid, nude; tarsus II, 17 ventral, 8 lateral and 2 dorsal tactile setae, 1 attenuate and 1 blunt sensory seta, *dt 2,* posterior *dt 1* solid, nude, *dt 3,* anterior *dt 1* hollow, nude; tarsus III, 20 ventrals, 8 laterals, trichoboth, *dt 1, 2* solid, nude, *dt 3* hollow, nude; tarsus IV, 19 ventrals, 6 laterals, trichoboth, setae of *dt 1* obliquely arranged, *dt 1, 2* solid, nude, *dt 3* hollow, nude.

Male: Unknown.

Type: Female, Urbana, Illinois, July 2, 1908, H. E. Ewing, under bark of cottonwood tree.

Location of type: The United States National Museum.

Remarks: The type specimen is incomplete and is 966 μ in length, slightly smaller than the specimen used for the redescription. Only

the type and five additional specimens were available for study; these latter specimens are identified by the following data: One female, six miles north of Chila, Puebla, Mexico, July 17, 1955, R. E. Beer, under stone; one female, Guatemala, at Brownsville, Texas, February 27, 1946, on *Odontoglossum* sp.; one female, south end of Cedar Mountains, Tooele Co., Utah, July 13, 1953, D. Porter; one female, Halsey, Thomas Co., Nebraska, 1954, W. F. Rapp, Jr., ex: duff; one female, Monte Alban, Oaxaca, Mexico, July 5, 1955, R. E. Beer, under rock.

In all the specimens, except the Utah female, the special sensory setae of tibia I are grouped in a small area distal to the trichoboth; in the Utah specimen, one of the attenuate sensory setae has migrated laterad of the trichoboth. The tactile setae of the three females from the more southern localities tend to have a greater diameter and to be more plumose than the same setae of the United States specimens.

The redescription and illustrations are based primarily on the female from Monte Alban, Oaxaca, Mexico.

Spinibdella depressa (Ewing), new combination

(Figs. 62, 119, 120, 158, 175)

Bdella depressa Ewing, 1909, Can. Ent., vol. 41, no. 4, p. 125.
Bdella virgata Ewing, 1910, Univ. Stud., Univ. Illinois, vol. 3, no. 6, p. 70 (new synonym).
Bdella chapultepecensis Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 177 (new synonym).
Bdella rio-lermensis Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 178 (new synonym).

Spinibdella depressa is closely related to *S. bifurcata,* sp. nov., but can be distinguished by the positions of the lateral propodosomal setae and the number of eyes. *S. depressa* has the lateral propodosomals approximate to the anterior sensilla rather than midway between the anterior and posterior sensilla, and has one pair of eyes rather than two pairs.

Female: Color in life light red with large black spots at posterolateral margins of the dorsal propodosoma. Body narrow, strongly constricted; length, including gnathosoma, 753 μ. *Gnathosoma:* Length, 195 μ; palpus (fig. 62) short, one half of tibiotarsus extending beyond hypostome; measurements: I, 14 μ; II plus III, 136 μ; IV, 17 μ; V, 40 μ; *des,* 168 μ; *ves,* 119 μ. Chelicera finely striated, 182 μ in length; setae inserted as in fig. 33. Gnathosoma striated; dorsal hypostomal setae small, 17 μ in length. *Dorsal propodosoma* (fig. 158): Striae sparsely broken; lateral propodosomals nude, 34 μ in length; median propodosomals plumose, 39 μ

in length; posterior pair of eyes wanting, former position indicated by striae forming teardrop pattern; distance between anterior sensilla, 45 μ. *Dorsal hysterosoma:* Setae plumose; length of internal humeral, 34 μ, less than one half of first interspace; external humeral, 34 μ in length; sacrals and clunals in subtrapazoidal arrangement, external clunals lateral to termination of cleft. *Anal region:* Border striae parallel; 1 pair of anal setae; paranals wanting; postanals at posterior two thirds of cleft, anterior to external clunals. *Genital region:* Each genital plate with 9 equal genital setae in linear arrangement; 11 pairs of paragenitals; 4 median unpaired paragenitals, anterior unpaired seta between coxae III; genital discs small, 2 pairs in anterior half of vestibule, 1 pair in caudal fourth; ovipositor with 12 subapical and 6 postmedial setae. *Legs* (figs. 119, 120): Claws small, unadorned, shorter than pretarsus; measurements: tibia I, 52 μ; tarsus I, 65 μ; tibia II, 49 μ; tarsus II, 65 μ. Chaetotaxy: coxae I-IV, 9, 8, 7, 5 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 7, 8, 7, 3 tactile setae; telofemora I-IV, 5, 5, 4, 5 tactiles; genua I-III, 6 tactiles and 1 duplex seta each; genu IV, 7 tactiles; tibia I, 11 tactiles, 1 blunt and 1 attenuate sensory seta, 1 attenuate peg, trichoboth; tibia II, 7 tactiles, 1 recessed blunt sensory seta; tibia III, 12 tactiles, 1 attenuate sensory seta; tibia IV, 11 tactiles, trichoboth; tarsus I, 13 ventrals, 4 lateral and 2 dorsal tactiles, 1 attenuate and 2 blunt sensory setae, *dt 1, 3* hollow, nude, *dt 2* solid, nude; tarsus II, as in tarsus I except lacking 1 attenuate sensory seta and posterior *dt 1* solid, nude; tarsi III-IV, 13 ventrals, 4 laterals, trichoboth, *dt 1, 2* solid, nude, *dt 3* hollow, nude.

Male: Identical to female except in genital region: 12-13 pairs of genital setae; amphioid sclerites as in fig. 175.

Type: Female, Arcola, Illinois, July 4, 1908, H. E. Ewing, under bark.

Location of type: The United States National Museum.

Remarks: The following types were also available for study: *Bdella virgata* Ewing, female, Mahomet, Illinois, April 17, 1908, H. E. Ewing, under bark; *Bdella rio-lermensis* Baker and Balock, female, Rio Lerma, Mexico-Toluca Highway, Mexico, January 24, 1943, E. W. Baker, lichens; *Bdella chapultepecensis* Baker and Balock, male, Chapultepec Park, Mexico, Distrito Federal, Mexico, March 16, 1943, E. W. Baker, lichens. Additional males and females, totaling thirty-six specimens, were examined from Mexico (San

Luis Potosí, México, Morelos) and the United States (Texas, Maryland, Arkansas, Kansas, Illinois, New Jersey, Connecticut).

Of the widely distributed species, this group exhibits the least amount of variation. Total length varies from 590 μ to 780 μ, and only occasionally do the tactile setae of the legs vary from one more, to one less, than the numbers indicated in the description. Drawings of a male from: Palmetto State Park, Texas, April 4, 1954, R. E. Beer, spanish moss.

Spinibdella bifurcata, sp. nov.

(Figs. 1, 2, 63, 117, 118, 162, 174)

This species is closely related to *Spinibdella ornata,* sp. nov., but is distinguished by having one blunt sensory seta deeply recessed on tibia II rather than one blunt and one attenuate sensory seta. The amphioid sclerites of the males are unique in both species (figs. 174, 176).

Female: Color unknown. Body (figs. 1, 2) narrow, strongly constricted; length, including gnathosoma, 702 μ. *Gnathosoma:* Length, 178 μ; palpus (fig. 63) short, tibiotarsus extending beyond hypostome; measurements: I, 9 μ; II plus III, 125 μ; IV, 18 μ; V, 31 μ; *des,* 202 μ; *ves,* 135 μ. Chelicera striated, 167 μ in length; setae as in fig. 33. Gnathosoma striated; dorsal hypostomal setae wanting. *Dorsal propodosoma* (figs. 1, 162): Striae sparsely broken; lateral propodosomals nude, 48 μ in length; median propodosomals finely plumose, 51 μ in length; eyes separated by distance equal to diameter of anterior pair, interval between eyes with longitudinal striae; distance between anterior sensilla, 44 μ. *Dorsal hysterosoma:* Setae finely plumose; length of internal humeral, 53 μ, approximately equal to first interspace; external humeral, 55 μ in length; sacrals in subtrapazoidal arrangement, external clunals wanting. *Anal region* (fig. 2): Border striae parallel; 2 pairs of anal setae; 1 pair of paranals; postanals flanking termination of cleft, shorter than clunals. *Genital region* (fig. 2): Each genital plate with 9 equal setae arranged in two rows; 15 pairs of paragenitals, anterior 3 pairs between coxae IV; median unpaired seta between coxae III wanting; genital discs small, distant; ovipositor with 12 subapical, 6 postmedial setae. *Legs* (figs. 117, 118): Claws unadorned, small, shorter than pretarsus; measurements: tibia I, 55 μ; tarsus I, 71 μ; tibia II, 48 μ; tarsus II, 70 μ. Chaetotaxy: coxae I-IV, 9, 8, 7, 6 tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 8, 8, 7, 3 tactile setae; telofemora I-IV, 6, 5, 4, 5 tactile setae; genu I, 5 tactiles, 1 duplex seta; genua II-III, 6 tactiles and 1 duplex

seta each; genu IV, 7 tactiles; tibia I, 14 tactiles, 1 attenuate and 1 blunt sensory seta, trichoboth; tibia II, 13 tactiles, 1 recessed, blunt sensory seta; tibia III, 15 tactiles, 1 attenuate sensory seta; tibia IV, 15 tactiles, trichoboth; tarsus I, 17 tactiles, 5 lateral and 2 dorsal tactiles, 1 attenuate and 2 blunt sensory setae, *dt 1, 3* hollow, nude, *dt 2* solid, nude; tarsus II, 15 ventrals, 5 lateral and 2 dorsal tactiles, 2 blunt sensory setae, *dt 2*, anterior *dt 1* solid, nude, *dt 3*, posterior *dt 1* hollow, nude; tarsus III, 18 ventrals, 8 laterals, trichoboth, *dt 1, 2* solid, nude, *dt 3* hollow, nude; tarsus IV, 17 ventrals, 6 laterals, trichoboth, dorsoterminals as in tarsus III.

Male: Identical to female except in genital region; each genital plate with 14 setae; amphioid sclerites as in fig. 174.

Holotype: Male, 10 miles west of Tuxtla Gutierrez, Chiapas, Mexico, July 8, 1955, R. E. Beer, under rock.

Allotype: Female, 16 miles north of Juchitan, Oaxaca, Mexico, July 2, 1955, R. E. Beer, free living on various plants.

Paratypes: Six males, five females, same data as the holotype; one female, same data as allotype; two males, 8 miles south of Nochistlan, Oaxaca, Mexico, June 30, 1955, R. E. Beer, under rock; two males, Monte Alban, Oaxaca, Mexico, July 17, 1955, R. E. Beer, under rock; one male, same data as the preceding, except collected July 15, 1955; one female, Huajuapam de Leon, Oaxaca, Mexico, July 17, 1955, R. E. Beer, under rock; one male, 17 miles north of Tehuitzingo, Puebla, Mexico, July 17, 1955, R. E. Beer, under rock; one male, one female, 3 miles north of Manzanillo, Michoacán, Mexico, July 26, 1955, R. E. Beer, on beach under coconut hull; one female, Mexico, at Brownsville, Texas, July 27, 1952, Smith, with pineapple fruit; one male, one female, 10 miles north of Edinburg, Texas, April 4, 1954, R. E. Beer, under log; two females, Corpus Christi State Park, Texas, August 6, 1955, R. E. Beer, under rock.

Location of types: The holotype, allotype, and twenty paratypes are deposited in the Snow Entomological Museum; two paratypes are deposited in each of the following: the United States National Museum, the South Australian Museum, and the British Museum (Natural History).

Remarks: The normally bifurcate seta on each of the amphioid sclerites (fig. 174) is undivided in one specimen, the resultant seta is unilaterally plumose. The genital plates of the female bear eight to ten pairs of setae, those of the males, thirteen to fourteen pairs. Other than these variations in the genital region and in total length,

which varies from 617 μ to 930 μ, the characteristic structures of this species are constant. This species is named *bifurcata* because of the unique structure of a median seta on each of the male amphioid sclerites. Drawings of the holotype.

Spinibdella cronini (Baker and Balock), new combination
(Figs. 65, 125, 126, 159, 160)

Bdella cronini Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7 p. 178.

The longitudinally or obliquely directed striae in the center of the propodosomal shield distinguishes this species from the closely related *Spinibdella ornata*, sp. nov., in which the striae are horizontally directed.

Female: Color in life pale red with darker markings on dorsolateral propodosoma. Body elongate, strongly constricted; length, including gnathosoma, 753μ (717-1257 μ). *Gnathosoma:* Length, 211 μ (194-247 μ); palpus (fig. 65) short, tibiotarsus extending beyond hypostome; measurements: I, 10 μ (9-15 μ); II plus III, 152 μ (126-175 μ); IV, 22 μ (21-27 μ); V, 36 μ (33-43 μ); *des*, 201 μ (170-254 μ); *ves*, 131 μ (122-167 μ). Chelicera striated, 196 μ (177-226 μ) in length; setae inserted as in fig. 33. Gnathosoma striated; dorsal hypostomal setae small, approximately 16 μ in length. *Dorsal propodosoma* (figs. 159, 160): Striae sparsely broken; lateral propodosomals thickened, nude (to slightly plumose), 49 μ (47-98 μ) in length; median propodosomals thickened, nude to plumose, 74 μ (53-82 μ) in length; eyes separated by distance equal to 2 diameters of anterior pair, interval between eyes with longitudinal striae; distance betwen anterior sensilla, 41 μ (41-76 μ). *Dorsal hysterosoma:* Setae thickened, nude (to plumose); length of internal humeral, 76 μ (54-118 μ), approximately equal to first interspace; external humeral, 69 μ (49-77 μ) in length; sacrals and clunals in subtrapazoidal arrangement. *Anal region:* Border striae parallel; 2 pairs of anal setae; paranals wanting; postanals flanking termination of cleft, shorter than clunals. *Genital region:* Each genital plate with 13 (13-16) equal, basally constricted setae in irregular linear arrangement; 21 (21-23) pairs of paragenital setae, anterior pairs between coxae III and IV; 2 (2-3) median, unpaired paragenital setae, anterior unpaired seta between coxae III; genital discs small, 2 pairs proximate in anterior half of vestibule, 1 pair in caudal one fourth; ovipositor short, seen only in axial view, 6 (5) pairs of setae anterior, 3 pairs posterior of center. *Legs* (figs. 125, 126): Claws nude, small, shorter than

pretarsus; measurements: tibia I, 58 μ (49-72 μ); tarsus I, 77 μ (65-97 μ); tibia II, 50 μ (45-65 μ); tarsus II, 76 μ (63-93 μ). Chaetotaxy: coxae I-IV, 7 (6), 7 (6-8), 7 (8), 6 (5) tactile setae; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 7, 7 (8), 5, 3 tactile setae; telofemora I-IV, 5, 5, 4, 4 (3) tactiles; genua I-IV, 5, 5, 5, 6 tactiles; tibia I, 13 (12) tactiles, 1 attenuate sensory seta, 1 peg, trichoboth; tibia II, 12 (13) tactiles, 1 blunt sensory seta; tibia III, 11 (12) tactiles, 1 attenuate sensory seta; tibia IV, 14 tactiles, trichoboth; tarsus I, 12 (11) ventrals, 6 (7) lateral and 2 dorsal tactile setae, 2 blunt sensory setae, *dt 1, 2* solid, nude, *dt 3* solid, nude (one or both may be hollow, nude); tarsus II, 11 (10) ventrals, 6 lateral and 2 dorsal tactiles, 2 blunt sensory setae, *dt 1, 2* solid, nude, anterior *dt 3* solid, nude (hollow, nude), posterior *dt 3* hollow, nude; tarsus III, 12 (11) ventrals, 6 laterals, trichoboth, dorsoterminals as in leg II; tarsus IV, 14 (12-14) ventrals, 7 (6) laterals, trichoboth, *dt 1, 2* solid, nude, *dt 3* hollow, nude.

Male: Unknown.

Type: Tritonymph, Planada, California, June 13, 1936, E. W. Baker, lichens from fig tree.

Location of type: The United States National Museum, type no. 1462.

Remarks: One hundred and forty-six females were examined, which included specimens from: Mexico (México, Tamaulipas, Guerrero, Neuvo León, San Luis Potosí) and the United States (Texas, California, Utah, Colorado, Washington, Alabama, Maryland).

This is the only species studied in which a marked variation occurs in the pattern of the dorsal propodosomal shield. The striae in the central area of the pattern in the Mexican specimens are oblique (fig. 159), while the same striae in the United States (Utah) specimens are longitudinally directed (fig. 160). Variation in the forms of the dorsoterminal setae at the apex of the tarsi can not be related to geographic area, nor does correlation exist between the different striation patterns and the various combinations of dorsoterminal setae.

The redescription and figures are based on a female with the following data: Cedar Mountains, Tooele County, Utah, December 12, 1954, D. Allred, Ex: pack rat (*Neotoma*) nest. The specimen used for the illustration of the Mexican shield pattern was collected at: 6 miles northeast of Jalostitlan, Jalisco, Mexico, August 19, 1954, W. T. Atyeo, under rock, altitude 6,000 feet.

Spinibdella ornata, sp. nov.

(Figs. 64, 121, 122, 161, 176)

This species is closely related to *Spinibdella bifurcata,* sp. nov., but is unique in having the duplex setae on the proximal halves of the genua, rather than the distal halves, and one blunt and one attenuate sensory seta on tibia II, rather than one deeply recessed blunt sensory seta. The internal humerals of *Spinibdella ornata* are about one half the length of the first interspaces, whereas in S. *bifurcata,* the internal humerals equal the first interspaces. Males can be easily recognized by the branched setae on the amphioid sclerites (fig. 176).

Female: Color unknown. Body narrow, strongly constricted; length, including gnathosoma, 900 μ. *Gnathosoma:* Length, 252 μ; palpus (fig. 64) short; measurements: I, 10 μ; II plus III, 167 μ; IV, 21 μ; V, 36 μ; *des,* 245 μ; *ves,* 167 μ. Chelicera striated, 239 μ in length; setae as in fig. 33. Gnathosoma striated; dorsal hypostomal setae, 25 μ in length. *Dorsal propodosoma* (fig. 161): Striae sparsely broken; lateral propodosomals nude, 41 μ in length; eyes separated by distance equal to diameter of anterior pair, interval between eyes with longitudinal striae; distance between anterior sensilla, 53 μ. *Dorsal hysterosoma:* Setae finely branched; length of internal humeral, 37μ, approximately one half of first interspace; external humeral, 47 μ in length; sacrals and clunals in subtrapazoidal arrangement. *Anal region:* Border striae parallel, 2 pairs of anal setae, paranals wanting, postanals flanking termination of cleft. *Genital region:* Each genital plate with 10 small, attenuate setae in linear arrangement; 18 pairs of paragenitals, anterior pair between coxae IV; 2 median, unpaired setae anterior to genital aperture; genital discs equidistant, in posterior two thirds of vestibule; ovipositor with 12 subapical, 6 postmedial setae. *Legs* (figs. 121, 122): Claws with one row of lateral rays each; measurements: tibia I, 72 μ; tarsus I, 96 μ; tibia II, 61 μ; tarsus II, 90 μ. Chaetotaxy : coxae I-IV, 8, 7, 7, 6 tactile setae, length of each seta exceeding coxal width; trochanters I-IV, 1, 1, 2, 1 tactile setae; basifemora I-IV, 12, 8, 7, 3 tactile setae; telofemora I-IV, 9, 8, 5, 6 tactiles; genu I, 6 tactiles, 1 proximal duplex seta, 1 distal attenuate sensory seta; genua II-III, 6 tactiles and 1 proximal duplex seta each; genu IV, 8 tactiles; tibia I, 15 tactiles, 1 attenuate and 1 blunt sensory seta, 1 peg, trichoboth; tibia II, 13 tactiles, 1 attenuate and 1 blunt sensory seta; tibia III, 12 tactiles, 1 attenuate sensory seta; tibia IV, 15 tactiles, trichoboth; tarsus I, 17 ventrals, 8 lateral

and 2 dorsal tactile setae, 1 attenuate and 2 blunt sensory setae, 1 peg, *dt 1, 3* hollow, nude, *dt 2* solid, nude; tarsus II, 17 ventrals, 7 lateral and 1 dorsal tactile seta, 1 attenuate and 2 blunt sensory setae, 1 peg, *dt 1, 2* solid, nude, *dt 3* hollow, nude; tarsus III, 16 ventrals, 6 laterals, trichoboth, dorsoterminals as in tarsus II; tarsus IV, 17 ventrals, 5 laterals, trichoboth, setae of *dt 1* obliquely situated to each other, *dt 2, 3* as in tarsus II.

Male: Identical to female except in genital region: each genital plate with 17 equal setae, each about one half the length of female genital setae; amphioid sclerites as in fig. 176.

Holotype: Male, Bear Lake, Rocky Mountain National Park, Colorado, August 23, 1955, T. A. Woolley, moss and litter.

Allotype: Female, same data as holotype.

Paratypes: One female, same data as holotype; one female, Hope Valley, Alpine Co., California, July 22, 1955, N. A. Walker, lodge pole pine litter and humus, altitude 7,300 feet; one male, H. Cowell, Redwood State Park, 4 miles north of Santa Cruz, Santa Cruz Co., California, August 31, 1956, N. A. Walker, redwood litter, sample 294; one female, 3 miles north of Boulder Creek, Santa Cruz Co., California, August 31, 1956, N. A. Walker, redwood litter, sample 295.

Location of types: The holotype and three paratypes are deposited in the Snow Entomological Museum; the allotype at the Department of Zoology, Colorado A and M College, Fort Collins, Colorado; and one paratype is deposited at the United States National Museum.

Remarks: Variation between the Colorado and California specimens is not detectable. Total length varies from 660 μ to 923 μ, and the other measurements vary accordingly. This species is named *ornata* to call attention to the highly modified setae on the male amphioid sclerites. Drawings of the holotype.

Genus *Biscirus* Thor

Biscirus Thor, 1927, Ann. Mus. Leningrad, vol. 27, p. 135. (Type: *Bdella silvatica* Kramer, 1881 [by original designation].)

This genus is related to *Monotrichobdella*, but has two end setae rather than one. The palpal tibiotarsus is elongated and cylindrical, and in addition to the two end setae, has two other setae, as does the genu and the basifemur. The cheliceral setae do not extend beyond the tips of the chelae. The lateral propodosomal

setae are wanting; striation patterns on the dorsal propodosoma do not appear to be specific.

The majority of the species formally placed in this genu (Thor, 1931) appear to belong to *Thoribdella;* this would include such species as *Biscirus lapidarius* (Kramer), 1881; *B. intermedius* Thor, 1928; and *B. uncinatus* (Kramer), 1881. Only two species have been examined in the present study that definitely belong to this group, these are: *Biscirus silvaticus* (Kramer), 1881, and *B. thori* Womersley, 1933.

Biscirus silvaticus (Kramer)

(Figs. 10, 35, 67, 129, 130, 166, 177)

Bdella silvatica Kramer, 1881, Zeitsch. für Naturw., vol. 54, p. 445.

This species is related to the Australian species, *Biscirus thori* Womersley, but can be distinguished by the palpal genu being less than twice the length of the palpal telofemur, rather than the genu three times longer than the telofemur.

Female: Color in life dark red with deep blue blotches and black to purple eye spots. Body strongly constricted; length, including gnathosoma, 1210 μ (1100-1800 μ). *Gnathosoma:* Length, 349 μ (349-485 μ); palpus (fig. 67) with reduced number of setae; measurements: I, 14 μ (11-17 μ); II, 175 μ (175-491 μ); III, 29 μ (26-54 μ); IV, 43 μ (43-95 μ); V, 126 μ (114-221 μ); *des,* 235 μ (235-280 μ); *ves,* 170 μ (170-207 μ). Chelicera (fig. 10) elongate, striated, 345 μ (331-460 μ) in length; setae as figured. Hypostome striated, 349 μ (349-485 μ) in length; dorsal hypostomal setae wanting. *Dorsal propodosoma* (fig. 166): Striae coarsely broken; median propodosomals plumose, 65 μ (44-65 μ) in length; eyes separated by distance equal to diameter of anterior pair, interval between eyes with transverse striae; distance between anterior sensilla, 65 μ (65-103 μ). *Dorsal hysterosoma:* Setae plumose; length of internal humeral, 51 μ (37-51 μ), approximately one third of first interspace; external humeral, 61 μ (37-61 μ) in length; sacrals and clunals in gently curving transverse rows. *Anal region:* Border striae parallel; one pair of anal setae; 2 pairs of paranals; postanals flanking termination of cleft, equal in length to external clunals. *Genital region:* Each genital plate with 15 (14) thin, nude genital setae arranged in 2 irregular rows; 12 (13) pairs of paragenitals, anterior pair between coxae IV; genital discs of moderate size, equidistant; ovipositor with 14 subapical setae. *Legs* (figs.

129, 130): Claws shorter than pretarsus, each with one row of lateral rays; measurements: tibia I, 102 μ (102-158 μ); tarsus I, 177 μ (170-218 μ); tibia II, 96 μ (88-129 μ); tarsus II, 170 μ (160-207 μ). Chaetotaxy: coxae I-IV, 4, 4, 5, 4 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 8, 9, 7, 4 tactile setae; telofemora I-IV, 5, 5, 4, 3 tactile setae; genu I, 3 tactiles, 4 attenuate sensory setae; genu II, 4 tactiles, 1 attenuate sensory seta; genu III, 4 tactile setae, 1 attenuate sensory seta; genu IV, 4 tactile setae; tibia I, 12 tactile setae, 4 attenuate sensory setae, 1 peg, trichoboth; tibia II, 13 tactile setae, 1 attenuate and 1 blunt sensory seta; tibia IV, 11 tactile setae, trichoboth; tarsus I, 15 plumose ventrals, 6 lateral and 1 dorsal tactile seta, 2 attenuate and 2 blunt sensory setae, *dt 1, 3* hollow, nude, anterior *dt 2* wanting, posterior *dt 2* solid, plumose; tarsus II, 14 plumose ventrals, 6 lateral and 2 dorsal tactiles, 2 blunt sensory setae, *dt 1, 2* solid, nude, *dt 3* hollow, nude; tarsus III, 16 plumose ventrals, 18 laterals, trichoboth, dorsoterminals as in tarsus II; tarsus IV, 13 plumose ventrals, 7 laterals, trichoboth, 1 attenuate sensory seta proximal to trichoboth, *dt 1* reduced to one solid, nude seta, *dt 2, 3* as in tarsus II.

Male: Identical to female except in genital region; each genital plate with 19-20 setae; amphioid sclerites as in fig. 177.

Type: Europe.

Location of type: Unknown.

Remarks: Specimens were examined from: Mexico (Oaxaca, Durango, Nuevo León), Haiti, the United States (California, Mississippi, Kansas, Colorado, Maryland, Tennessee), Iceland, and Germany (near Ost-Holstein).

Typically, the median propodosomals divide the interval between the posterior sensilla into three approximately equal parts, but considerable migration occurs around these points. The median propodosomals can be anterior to a line connecting the posterior sensilla (fig. 166) or they can be on that line, and can be closer to the posterior sensilla than to themselves, or vice versa.

Redescription and figures of a female from: ten miles south of China, Nuevo León, Mexico, August 4, 1955, R. E. Beer, under rock. The figure of the amphioid sclerites was prepared from a male from: University of Kansas campus, Lawrence, Douglas Co., Kansas, May 5, 1954, D. E. Sbur, under rock.

Genus *Monotrichobdella* Baker and Balock

Monotrichobdella Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 176. (Type: *Monotrichobdella max-osburni* Baker and Balock, 1944 [by original designation].)

This unique genus is related to *Biscirus,* but has one palpal end seta rather than two. The palpal tibiotarsus is elongate and cylindrical, and in addition to the single apical seta, there are three other setae on this segment; the genu may have one or two setae and the basifemur has two setae. The distal cheliceral seta extends beyond the tips of the chela. The lateral propodosomal setae are wanting; striation patterns on the dorsal propodosoma are similar to *Biscirus* species.

Monotrichobdella maxosburni Baker and Balock

(Figs. 34, 68, 131, 132, 168)

Monotrichobdella max-osburni Baker and Balock, 1944, Proc. Ent. Soc. Washington, vol. 46, no. 7, p. 176.

To date this is a monotypic genus. Adults have not been examined, but nymphal forms have been studied from two localities.

Tritonymph: Color in life red. Body ovoid, weakly constricted; length, including gnathosoma, 1350 μ. *Gnathosoma:* Length, 341 μ; palpus (fig. 68) with distal two thirds of tibiotarsus extending beyond hypostome; measurements: I, 11 μ; II plus III, 211 μ; IV, 31 μ; V, 102 μ; end seta, 216 μ. Chelicera (fig. 34) elongate, finely striated, 210 μ in length; chela smooth, needlelike, fixed digit two thirds length of movable digit; setae as figured. Gnathosomal base striated; hypostome nonstriated; *vh 1,* 65 μ from apex; *vh 2,* 218 μ from apex; dorsal hypostomal setae wanting. *Dorsal propodosoma* (fig. 168): Coarsley broken striae; median propodosomals plumose, 54 μ in length; eyes separated by distance equal to diameter of the anterior pair; distance between anterior sensilla, 82 μ. *Dorsal hysterosoma:* Setae plumose; length of internal humeral, 58 μ, approximately one half of first interspace; external humeral, 58 μ in length; sacrals in strongly curving transverse row; external clunals wanting. *Genital region:* Each genital plate with 9 fine, equal setae in irregular linear arrangement; 11 pairs of paragenitals, 1 unpaired seta and anterior 2 pairs of paragenitals between coxae IV; genital discs small, anterior pair one third the length of vestibule from anterior end, posterior pairs in caudal third; genitalia wanting. *Anal region:* Border striae parallel; 2 pairs of anal setae; 2 pairs of paranals; postanals flanking termination of cleft, shorter than clunal setae. *Legs* (figs. 131, 132): Each claw with one row of

lateral rays; measurements: tibia I, 85 μ; tarsus I, 134 μ; tibia II, 82 μ; tarsus II, 128 μ. Chaetotaxy: coxae I-IV, 4, 3, 4, 3 tactile setae; trochanters I-IV, 1 tactile seta each; basifemora I-IV, 7, 7, 7, 4 tactile setae; telofemora I-IV, 5, 5, 4, 4 tactile setae; genua I-III, 4 tactile setae and 1 attenuate sensory seta each; genu IV, 4 tactile setae; tibia I, 8 tactile setae, 3 attenuate sensory setae, 1 solid, attenuate peg, trichoboth; tibia II, 9 tactile setae, 1 attenuate sensory seta, 1 recessed, blunt sensory seta; tibia III, 8 tactile setae, 1 attenuate sensory seta; tibia IV, 6 tactile setae, trichoboth; tarsus I, 10 plumose ventral setae, 6 lateral and 1 dorsal tactile seta, 2 attenuate and 2 blunt sensory setae, 1 solid, attenuate peg, *dt 1*, 2 solid, nude, *dt* 3 hollow, nude; tarsus II, 10 plumose ventrals, 6 lateral and 1 dorsal tactile seta, 2 blunt sensory setae, dorsoterminals as in tarsus I; tarsus III, 10 plumose ventrals, 6 laterals, trichoboth, dorsoterminals as in tarsus I; tarsus IV, 10 plumose ventrals, 4 laterals, trichoboth, 1 attenuate sensory seta proximal to trichoboth, dorsoterminals as in tarsus I.

Female, Male: Not examined.

Holotype: Tritonymph, near Tres Cumbres, Mexico-Cuernavaca Highway, Morelos, Mexico (alt. 10,000 ft.), January 7, 1943, J. W. Balock and J. G. Shaw, lichens.

Location of type: The United States National Museum, type no. 1459.

Remarks: In addition to the type, two other specimens were available: one deutonymph, same data as the holotype, and one protonymph from: Salazar, Distrito Federal, Mexico, F. Bonet, September 30, 1942, moss.

The unpaired paragenital seta is not present in the protonymphal and deutonymphal stages. In other species having this unpaired seta, it is present in all stages of development, therefore, it is possible that the holotype is an aberrant specimen and that a median, unpaired paragenital seta is not a characteristic of this species, or that the unpaired seta occurs in only the tritonymphal and adult stages. Drawings of the holotype.

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FIGURE 1

Fig. 1. Dorsal aspect of *Spinibdella bifurcata*, sp. nov.

a. chelicera
b. gnathosomal base
c. anterior sensillum
d. lateral propodosomal
e. lateral eye
f. median propodosomal
g. posterior sensillum
h. internal humeral
i. external humeral
j. internal dorsal
k. internal lumbral
l. internal sacral
m. external sacral
n. internal clunal
o. posterior anal
p. anal seta
q. anal cleft

Figure 1

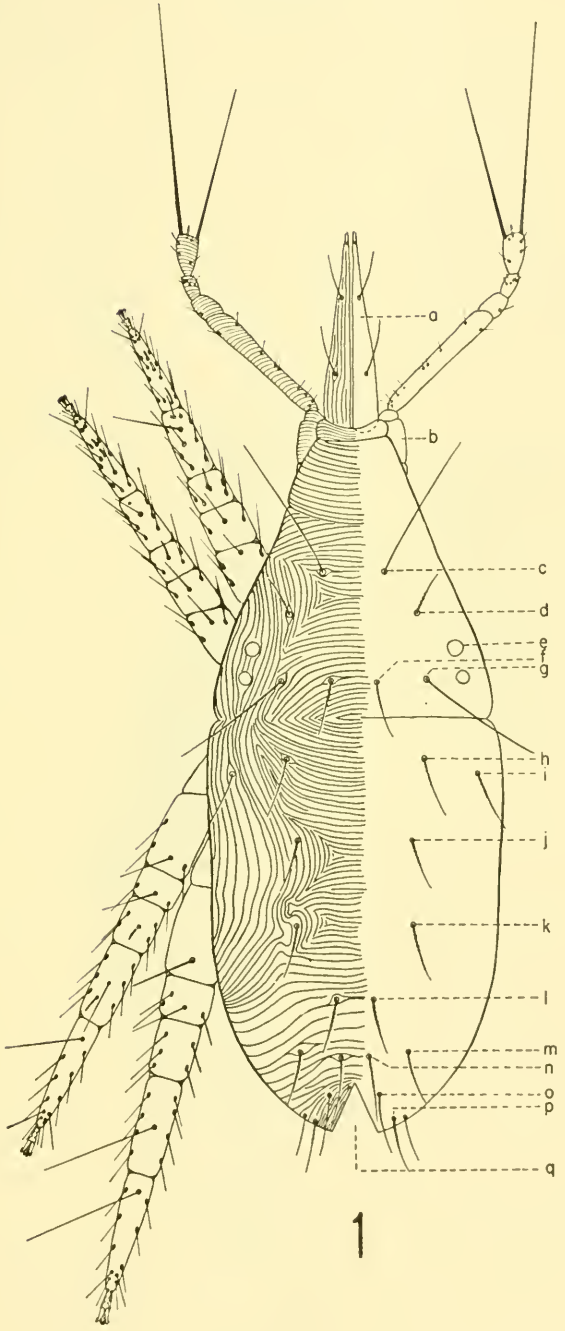
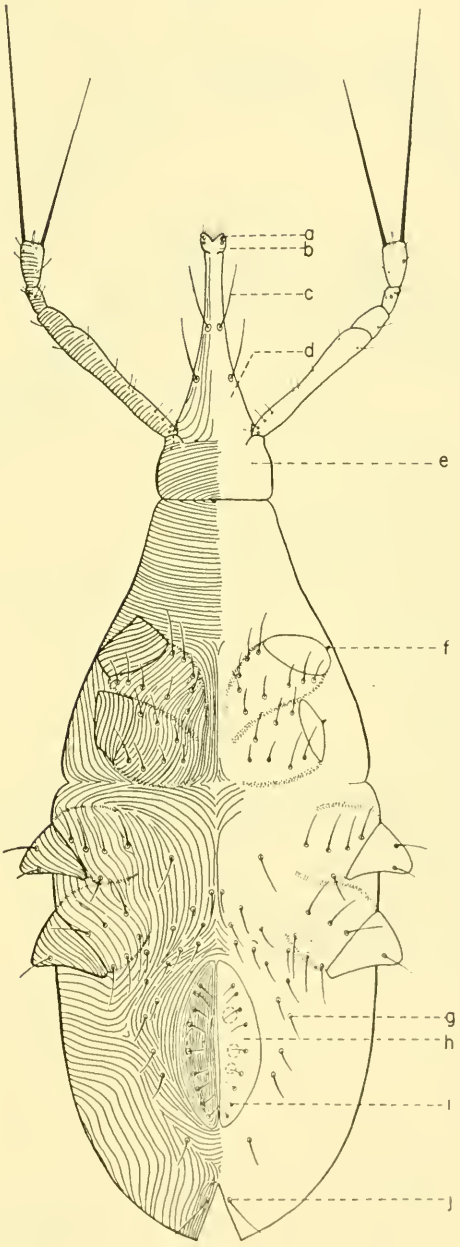


FIGURE 2

Fig. 2. Ventral aspect of *Spinibdella bifurcata,* sp. nov.

a. adornal setae
b. lateral lip
c. ventral hypostomal seta
d. buccal cone
e. gnathosomal base
f. coxal peg
g. paragenital seta
h. genital plate
i. genital seta
j. anal seta

Figure 2



2

FIGURES 3-11

Musculature of the appendages (figs. 3-6)

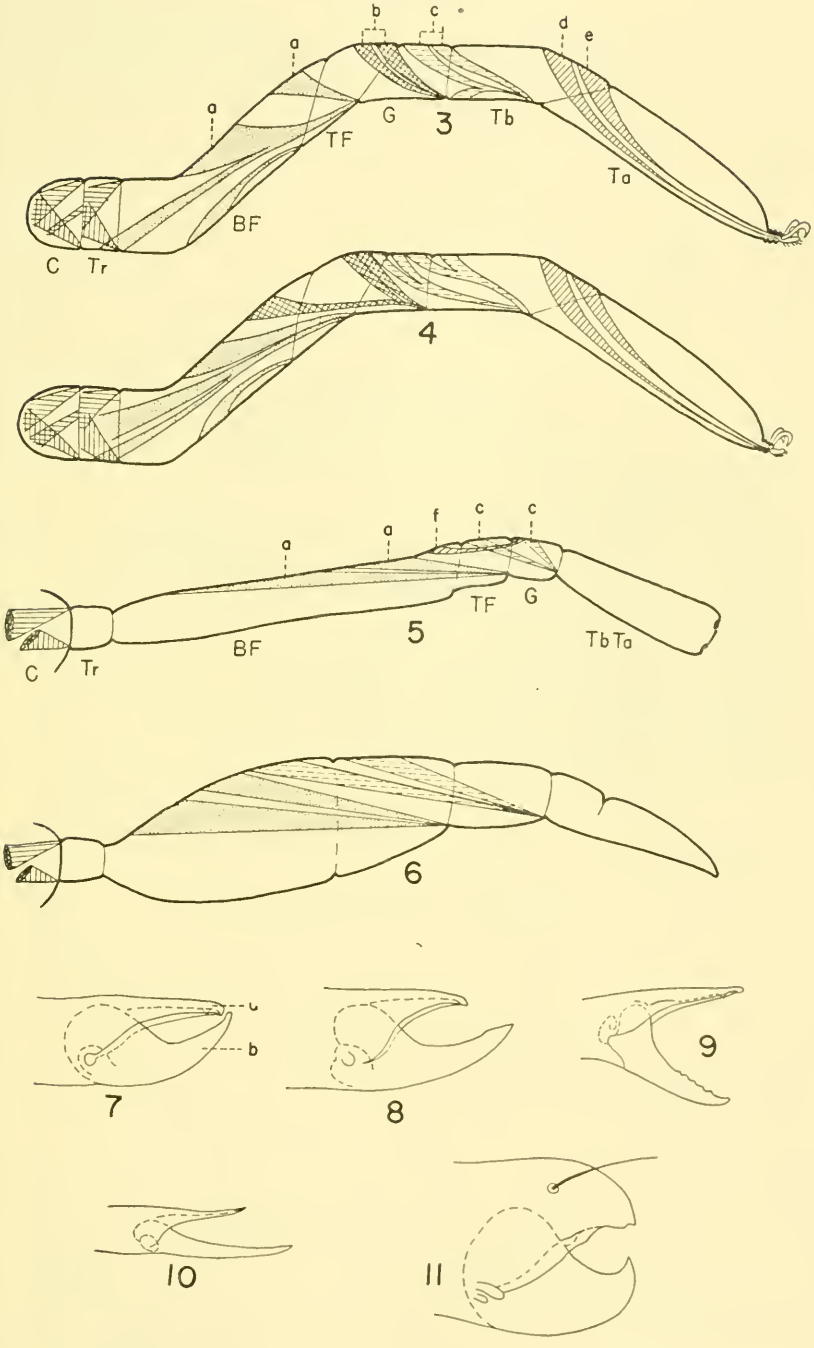
Fig. 3. Leg of *Bdella* species
Fig. 4. Leg of *Neomolgus* species
Fig. 5. Palpus of *Bdella* species
Fig. 6. Palpus of *Cunaxa* species

Legends for Figures 3-6

a. flexor muscle of genu
b. flexor muscle of tibia
c. flexor muscle of tarsus
d. depressor muscle of pretarsus
e. elevator muscle of pretarsus
f. extensor muscle of genu
C. coxa
Tr. trochanter
BF. basifemur
TF. telofemur
G. genu
Tb. tibia
Ta. tarsus
TbTa. fused tibiotarsus

Fig. 7. Chela of *Bdella longicornis*
a. fixed digit
b. movable digit
Fig. 8. Chela of *Thoribdella simplex*
Fig. 9. Chela of *Odontoscirus iota*
Fig. 10. Chela of *Biscirus silvaticus*
Fig. 11. Chela of *Cyta spuria*

Figures 3-11

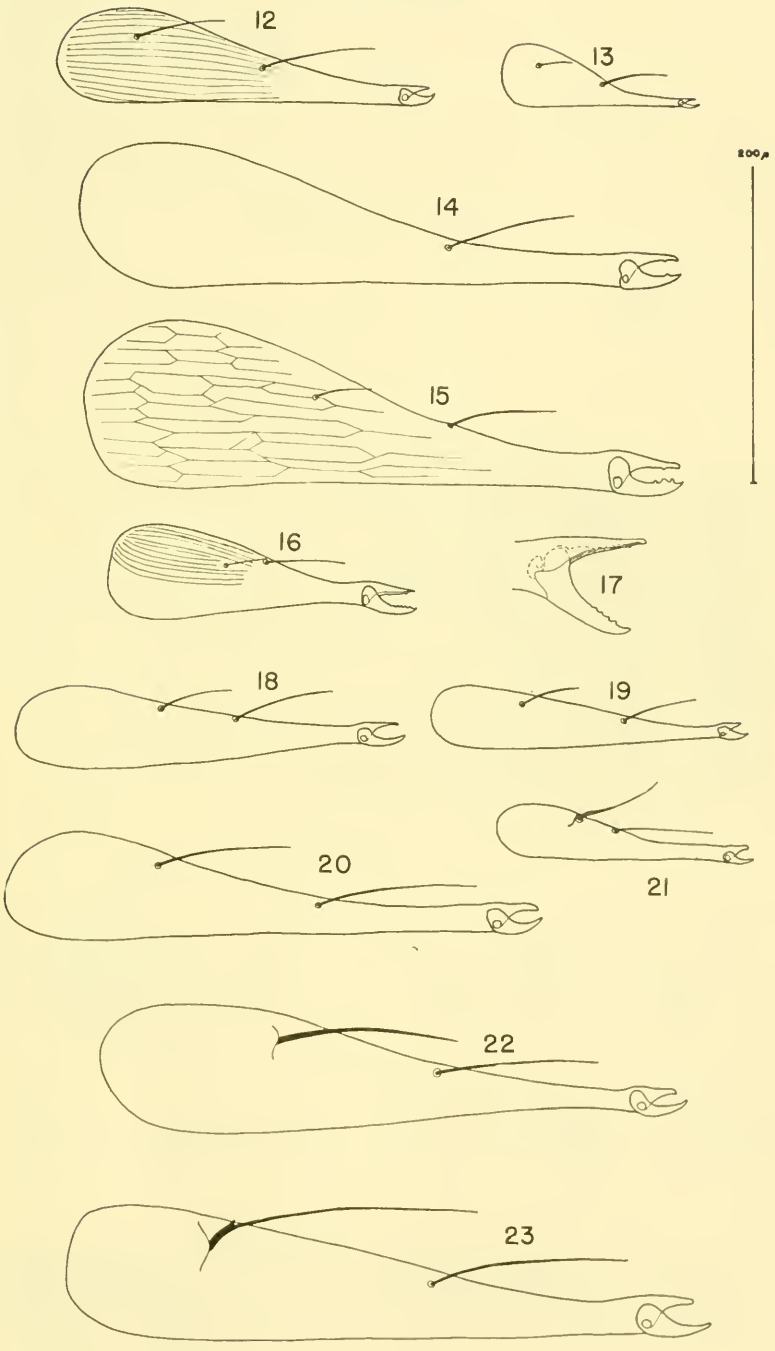


FIGURES 12-23

Lateral aspects of right chelicerae

Fig. 12. *Bdella longicornis*
Fig. 13. *Bdella mexicana*
Fig. 14. *Bdellodes longirostris*
Fig. 15. *Odontoscirus alpinus,* holotype
Fig. 16. *Odontoscirus iota,* holotype
Fig. 17. *Odontoscirus iota,* holotype
Fig. 18. *Octobdellodes hurdi,* holotype
Fig. 19. *Octobdellodes infrequens,* holotype
Fig. 20. *Octobdellodes infrequens,* allotype
Fig. 21. *Thoribdella meridionalis*
Fig. 22. *Thoribdella communis,* holotype
Fig. 23. *Thoribdella simplex,* holotype

Figures 12-23

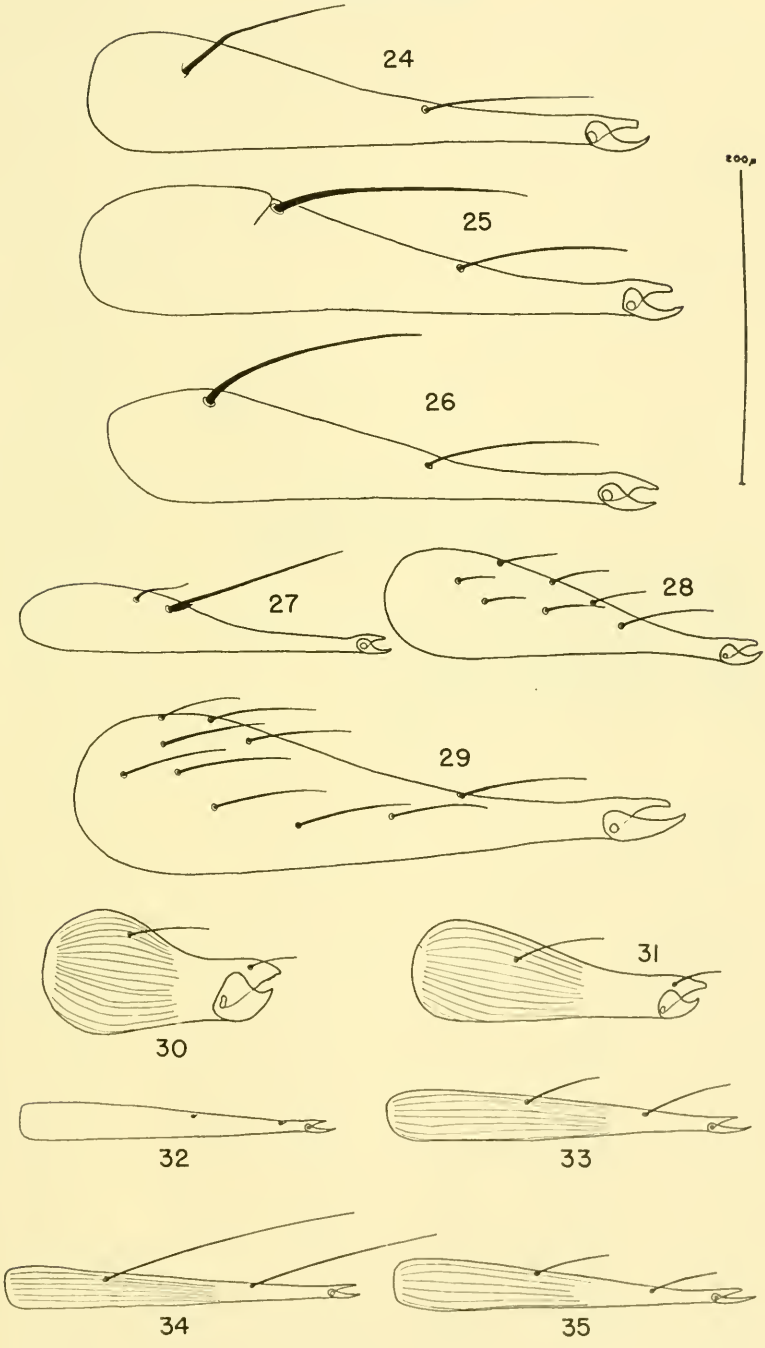


FIGURES 24-35

Lateral aspects of right chelicerae

Fig. 24. *Thoribdella truncata,* holotype
Fig. 25. *Thoribdella californica*
Fig. 26. *Thoribdella insolita,* holotype
Fig. 27. *Thoribdella spinosa,* holotype
Fig. 28. *Neomolgus mutabilis,* holotype
Fig. 29. *Neomolgus littoralis*
Fig. 30. *Cyta latirostris*
Fig. 31. *Cyta coerulipes*
Fig. 32. *Spinibdella tenuirostris,* type
Fig. 33. *Spinibdella corticis*
Fig. 34. *Monotrichobdella maxosburni,* type
Fig. 35. *Biscirus silvaticus*

Figures 24-35



FIGURES 36-41

Median aspects of left palpi

Fig. 36. *Bdella mexicana,* type
Fig. 37. *Bdella longicornis*
Fig. 38. *Bdella longistriata,* holotype
Fig. 39. *Bdella muscorum*
Fig. 40. *Bdella tropica,* holotype
Fig. 41. *Bdella distincta,* lectotype

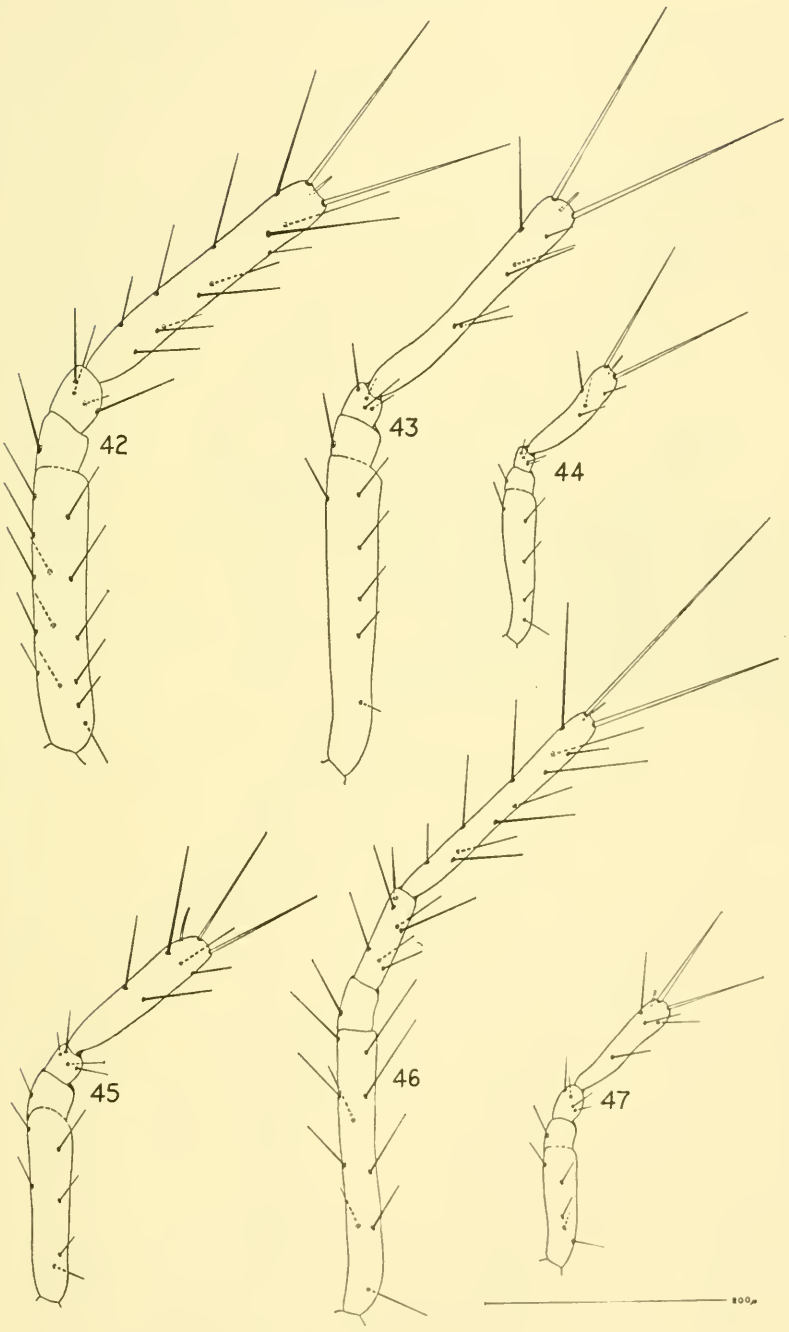
Figures 36-41

FIGURES 42-47

Median aspects of left palpi

Fig. 42. *Bdellodes longirostris*
Fig. 43. *Odontoscirus alpinus,* holotype
Fig. 44. *Odontoscirus iota,* holotype
Fig. 45. *Octobdellodes hurdi,* holotype
Fig. 46. *Octobdellodes infrequens,* holotype
Fig. 47. *Bdellodes bisetosa,* holotype

Figures 42-47

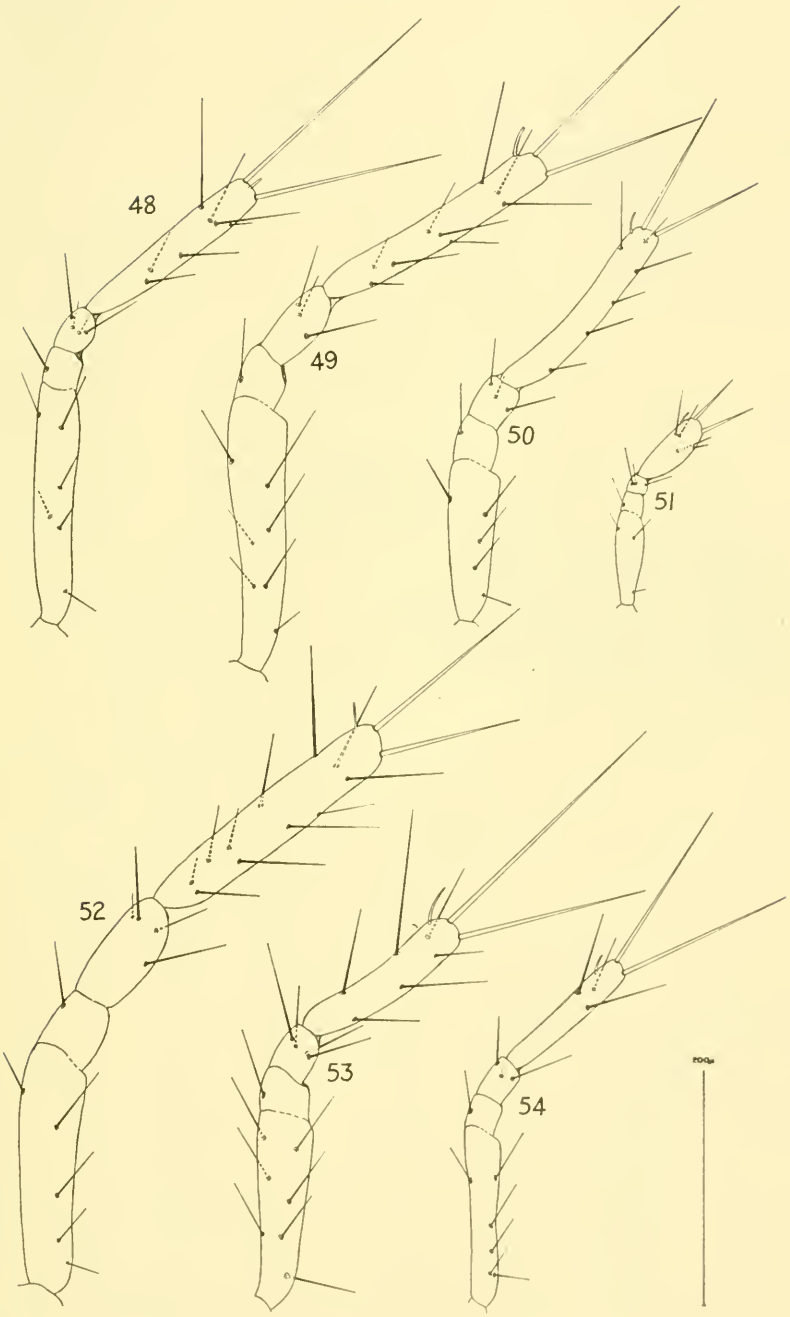


FIGURES 48-54

Median aspects of left palpi

Fig. 48. *Thoribdella communis,* holotype
Fig. 49. *Thoribdella simplex,* holotype
Fig. 50. *Thoribdella truncata,* holotype
Fig. 51. *Thoribdella meridionalis*
Fig. 52. *Thoribdella californica*
Fig. 53. *Thoribdella insolita,* holotype
Fig. 54. *Thoribdella spinosa,* holotype

Figures 48-54

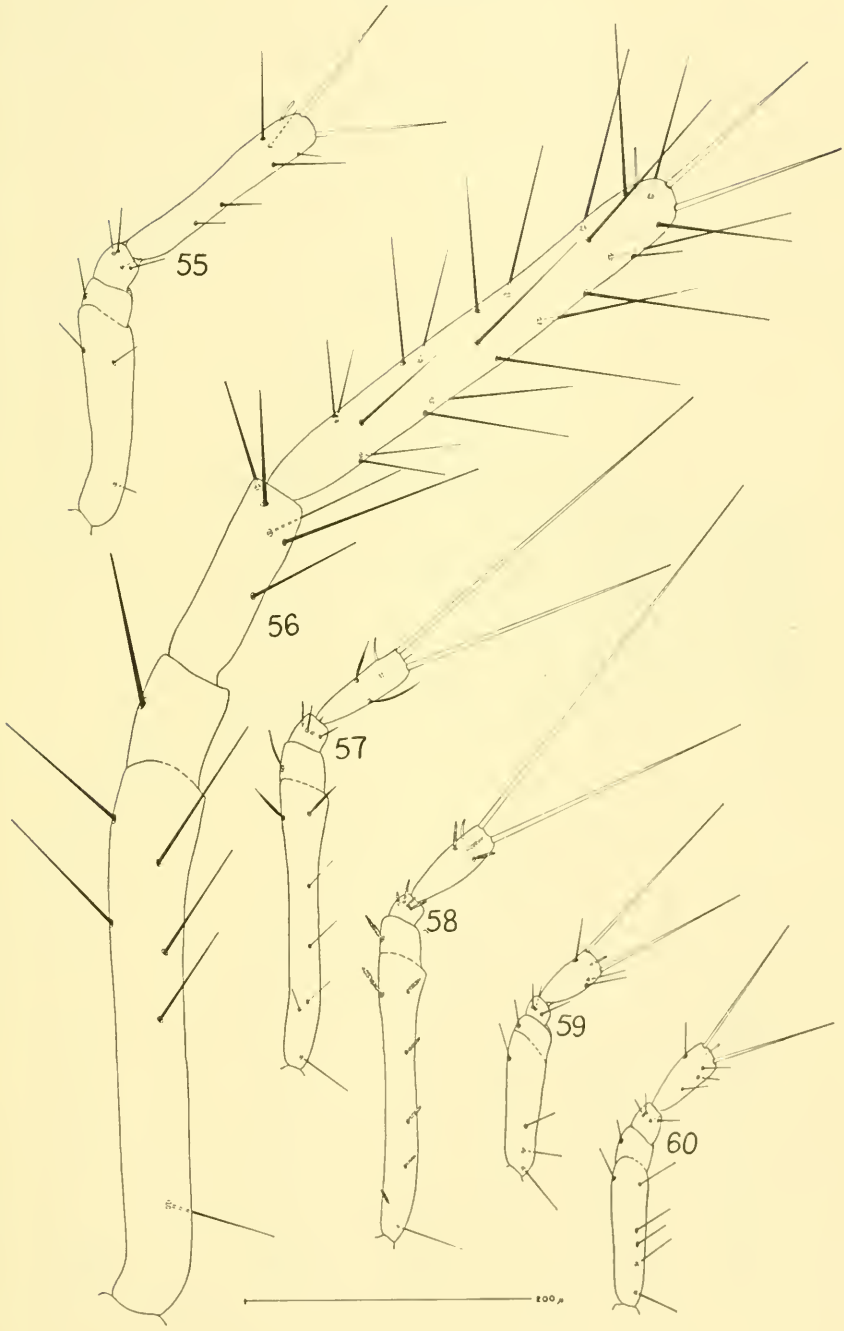


FIGURES 55-60

Median aspects of left palpi

Fig. 55. *Neomolgus mutabilis,* holotype
Fig. 56. *Neomolgus littoralis*
Fig. 57. *Cyta coerulipes,* nude setae
Fig. 58. *Cyta coerulipes,* plumose setae
Fig. 59. *Cyta spuria,* holotype
Fig. 60. *Cyta latirostris*

Figures 55-60



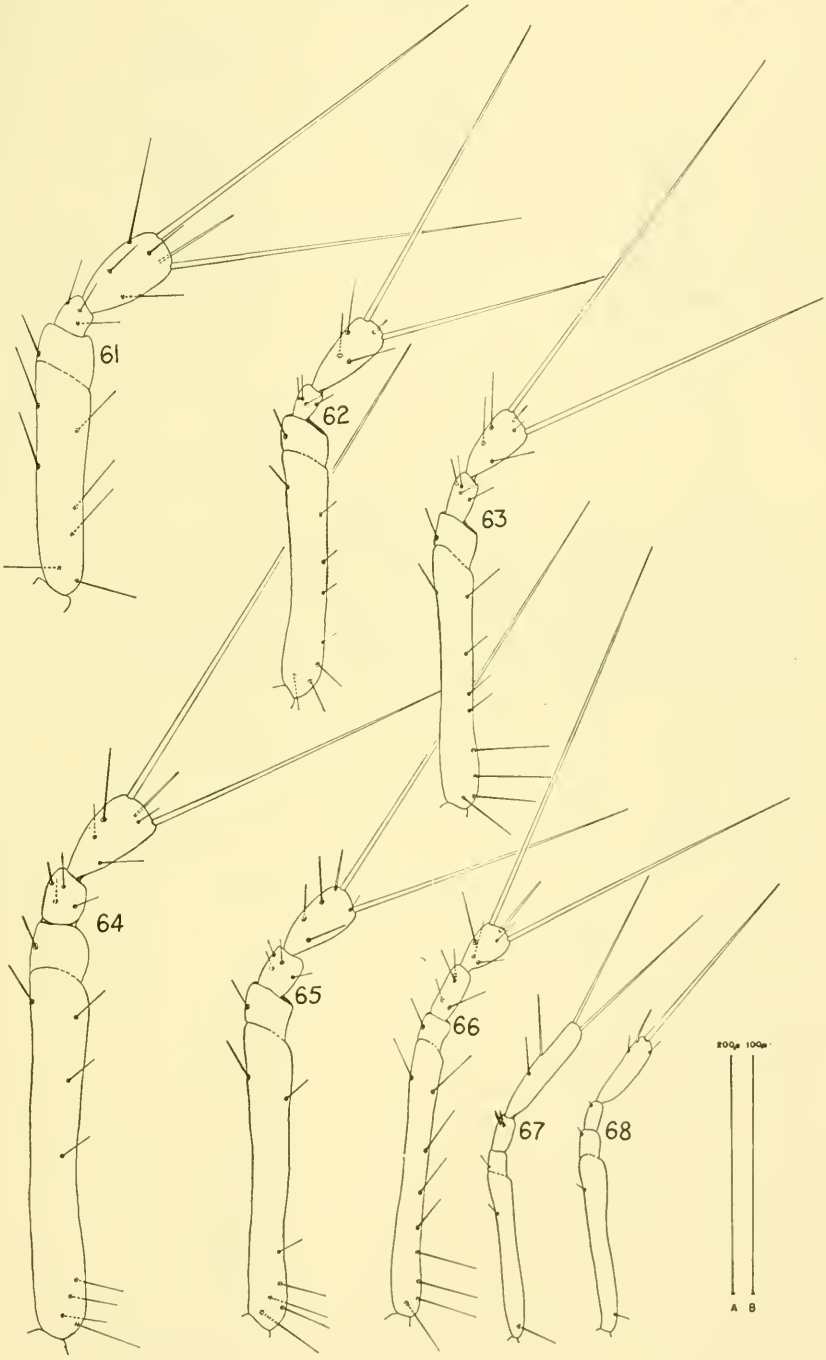
FIGURES 61-68

Median aspects of left palpi

(Figs. 61-65, scale A; figs. 66-68, scale B)

Fig. 61. *Spinibdella tenuirostris,* type
Fig. 62. *Spinibdella depressa*
Fig. 63. *Spinibdella bifurcata,* holotype
Fig. 64. *Spinibdella ornata,* holotype
Fig. 65. *Spinibdella cronini*
Fig. 66. *Spinibdella corticis*
Fig. 67. *Biscirus silvaticus*
Fig. 68. *Monotrichobdella maxosburni,* type (tritonymph)

Figures 61-68

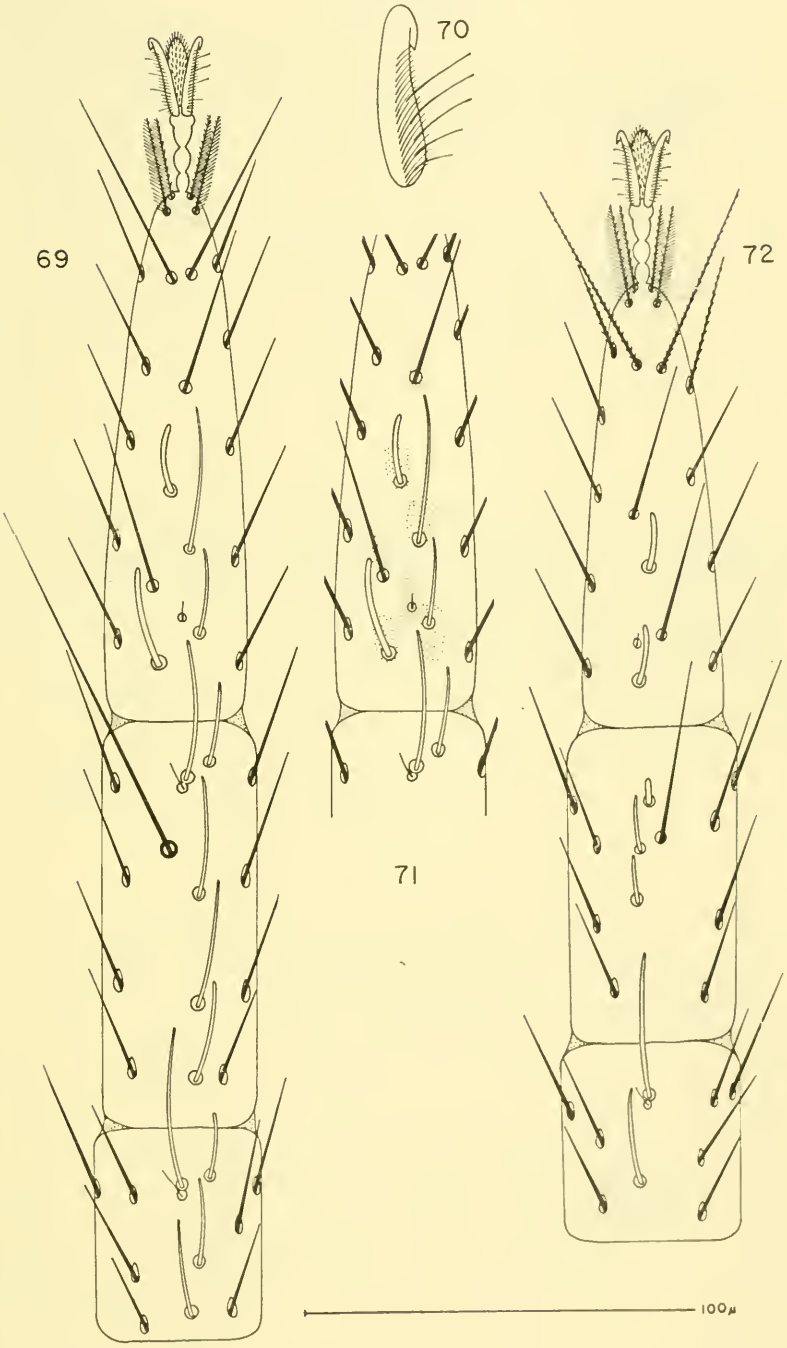


FIGURES 69-72

Dorsal aspect of legs I and II of *Bdella longicornis*

Fig. 69. Distal three segments of leg I
Fig. 70. Enlarged claw illustrating large and small lateral rays
Fig. 71. Tarsus I, stippled areas indicate extent of setal migration
Fig. 72. Distal three segments of leg II

Figures 69-72

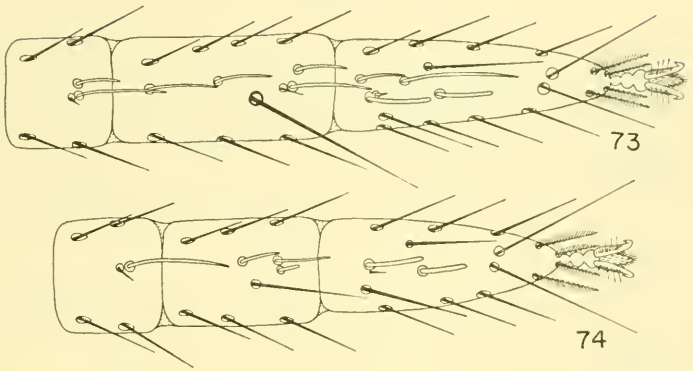


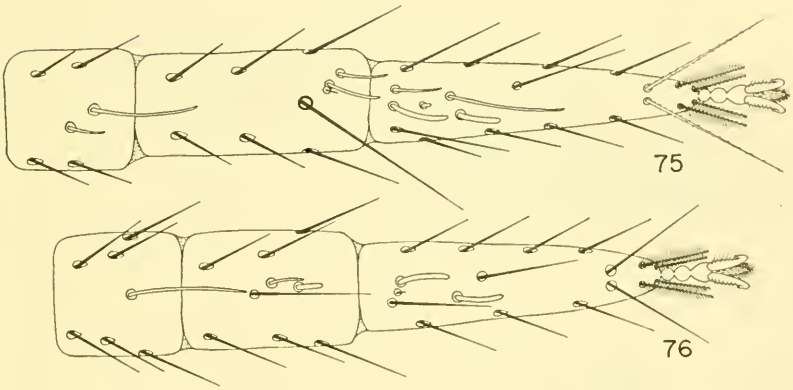
FIGURES 73-78

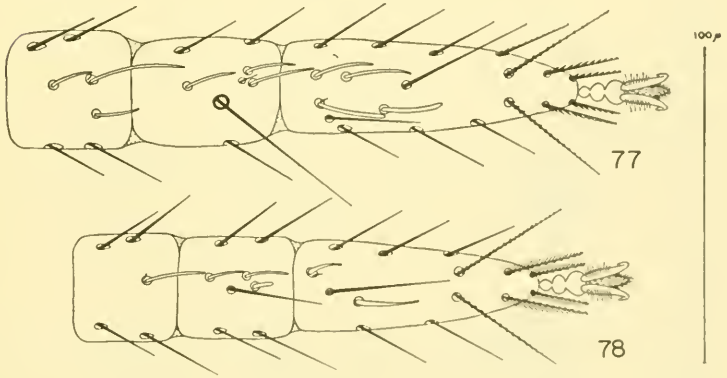
Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

Figs. 73, 74. *Bdella muscorum*
Figs. 75, 76. *Bdella longistriata,* holotype
Figs. 77, 78. *Bdella tropica,* holotype

Figures 73-78





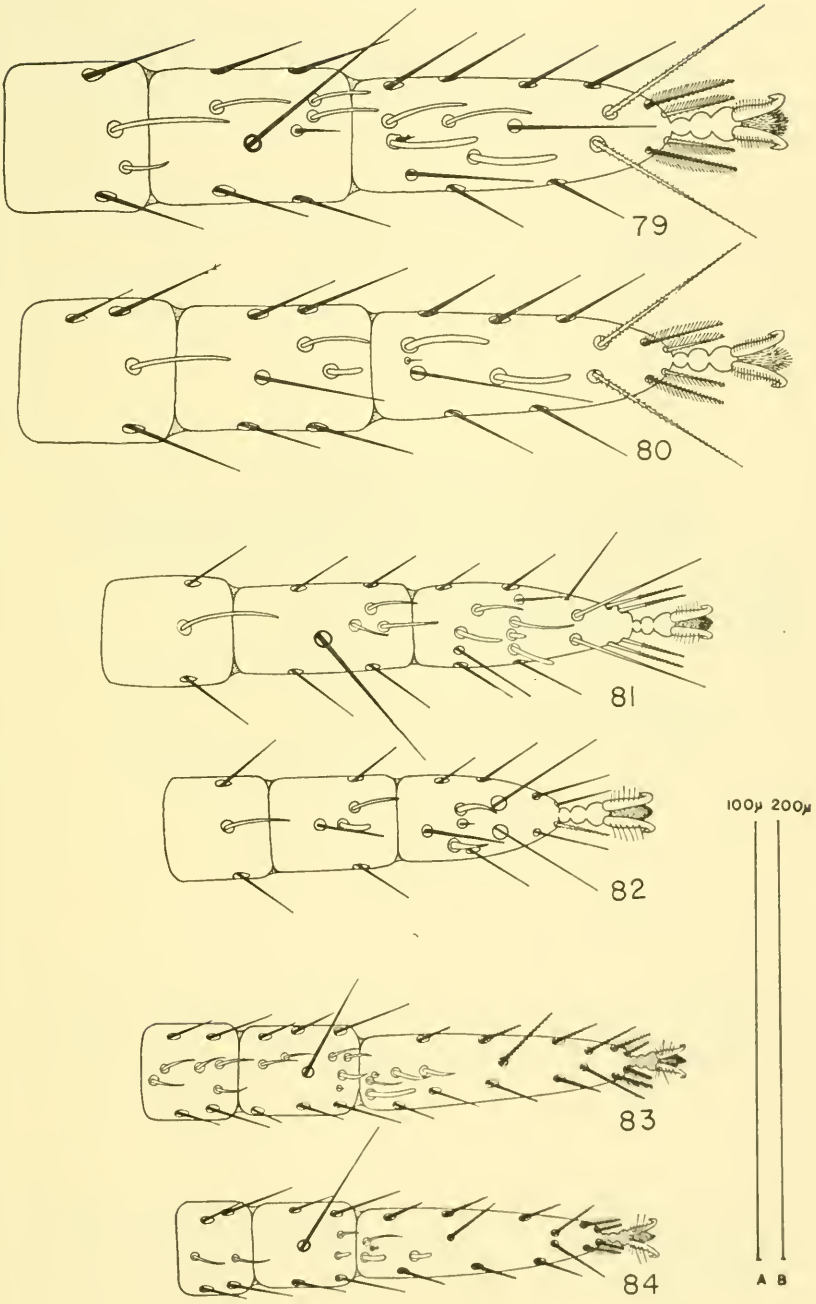


FIGURES 79-84

Dorsal aspect of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)
(Figs. 79-82, scale A; figs. 83-84, scale B)

Figs. 79, 80. *Bdella distincta,* lectotype
Figs. 81, 82. *Bdella mexicana,* type
Figs. 83, 84. *Odontoscirus iota,* holotype

Figures 79-84

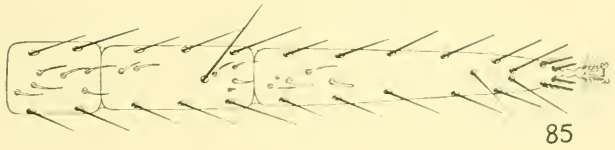


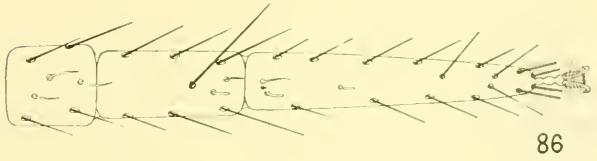
FIGURES 85-90

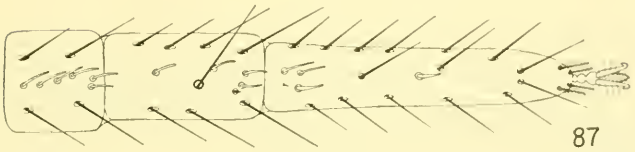
Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

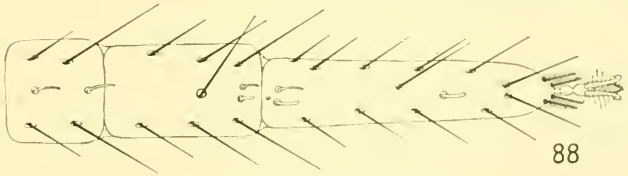
Figs. 85, 86. *Odontoscirus alpinus,* holotype
Figs. 87, 88. *Bdellodes longirostris*
Figs. 89, 90. *Octobdellodes infrequens,* holotype

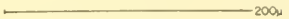
Figures 85-90

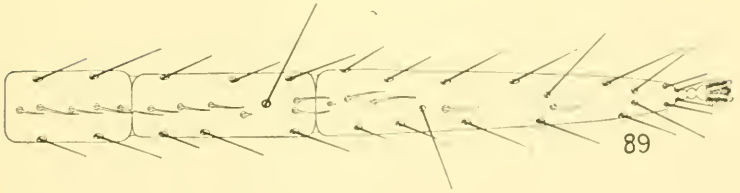










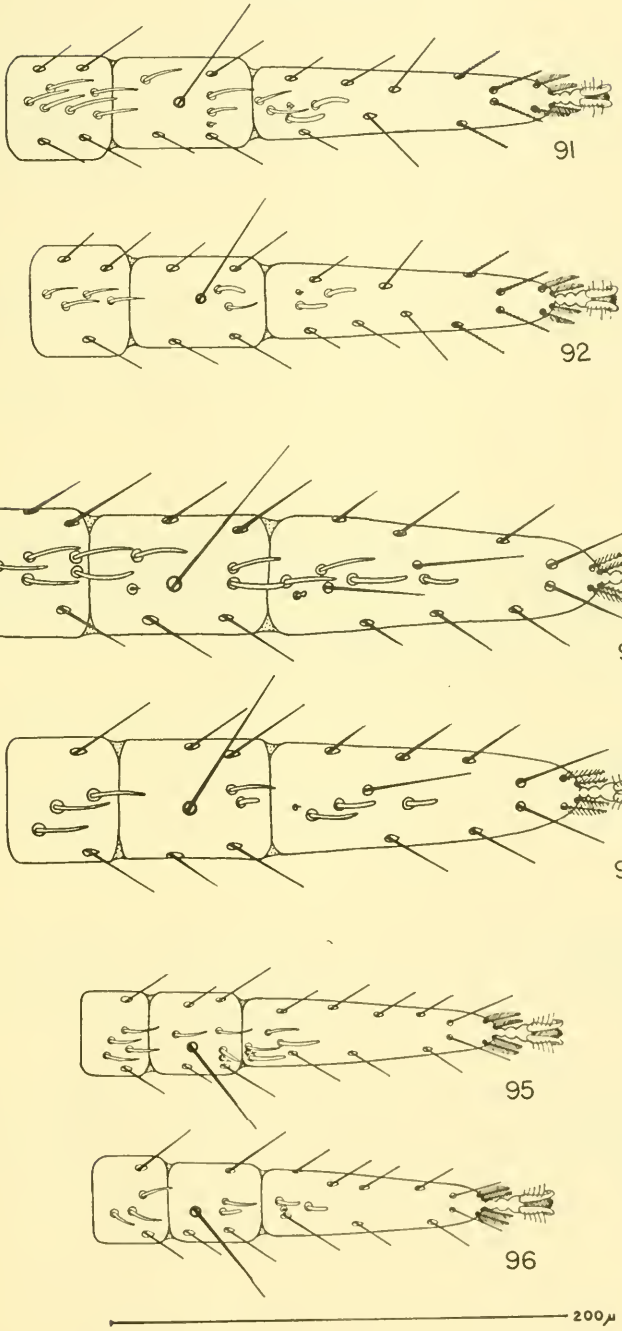


FIGURES 91-96

Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

Figs. 91, 92. *Bdellodes bisetosa,* holotype
Figs. 93, 94. *Octobdellodes hurdi,* holotype
Figs. 95, 96. *Thoribdella meridionalis*

Figures 91-96

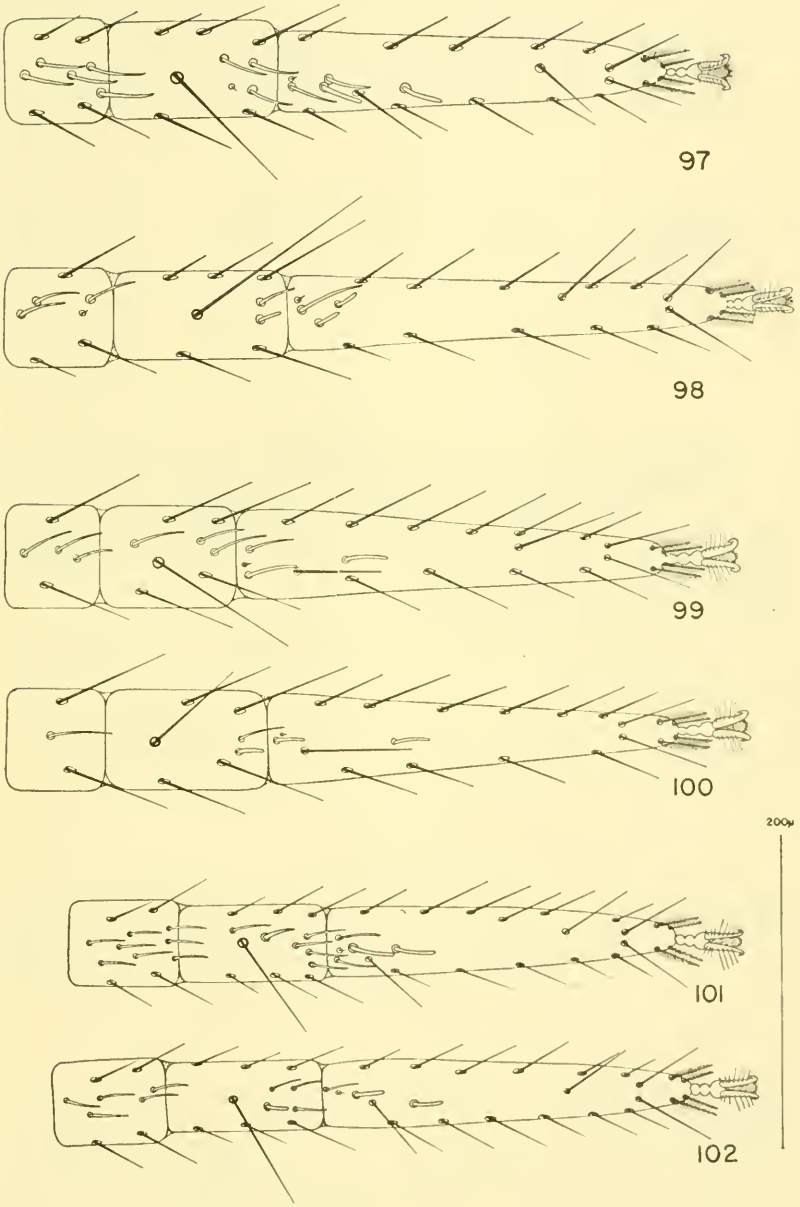


FIGURES 97-102

Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

Figs. 97, 98. *Thoribdella communis,* holotype
Figs. 99, 100. *Thoribdella insolita,* holotype
Figs. 101, 102. *Thoribdella truncata,* holotype

Figures 97-102

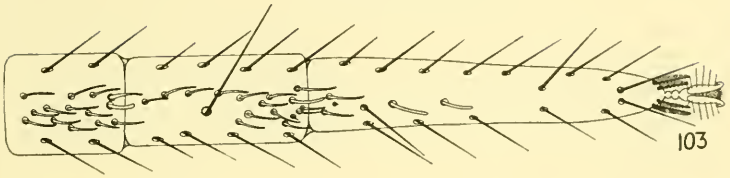


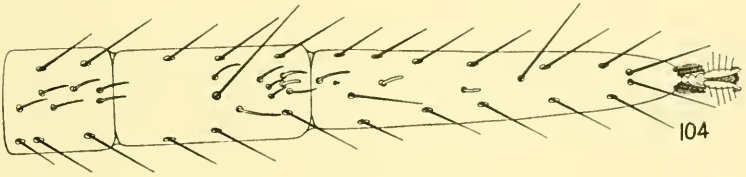
FIGURES 103-108

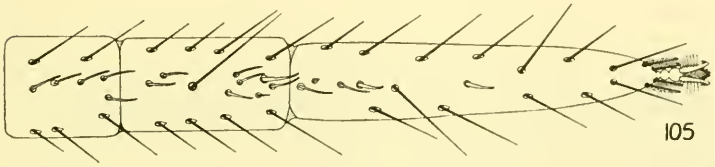
Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

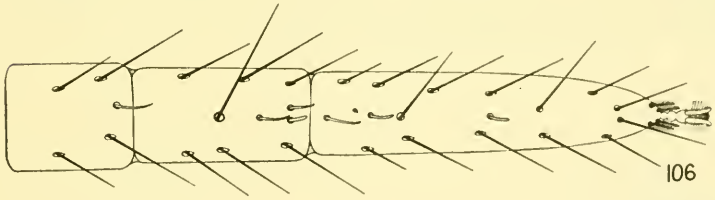
Figs. 103, 104. *Thoribdella simplex;* leg I, Kansas paratype; leg II, holotype
Figs. 105, 106. *Thoribdella californica*
Figs. 107, 108. *Neomolgus littoralis*

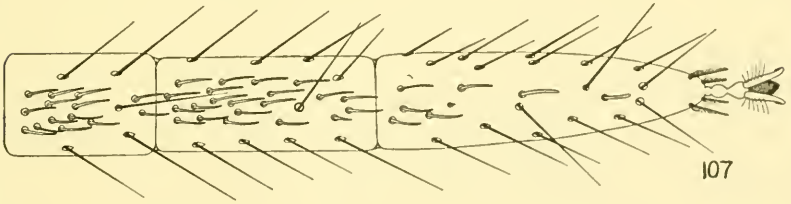
Figures 103-108

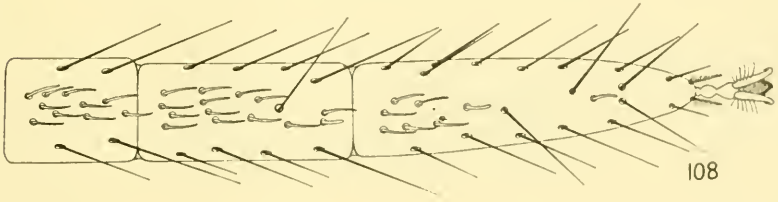










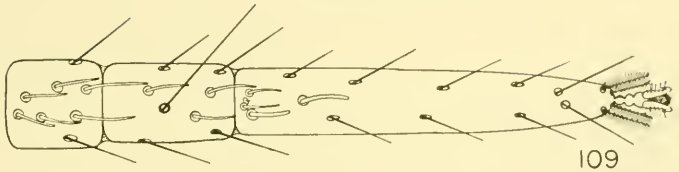


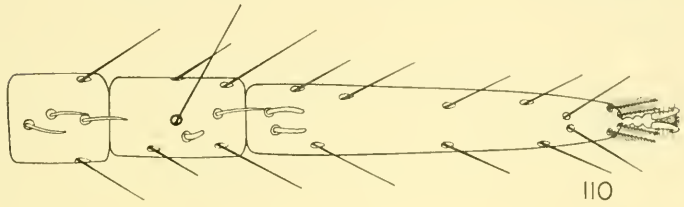
FIGURES 109-114

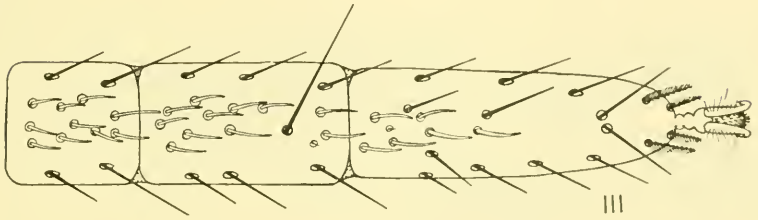
Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

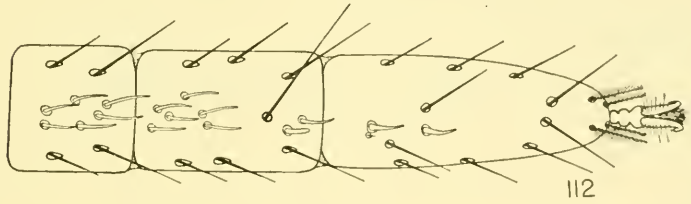
Figs. 109, 110. *Thoribdella spinosa,* holotype
Figs. 111, 112. *Neomolgus mutabilis,* holotype
Figs. 113, 114. *Cyta spuria,* holotype

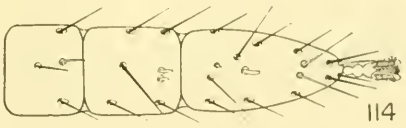
Figures 109-114









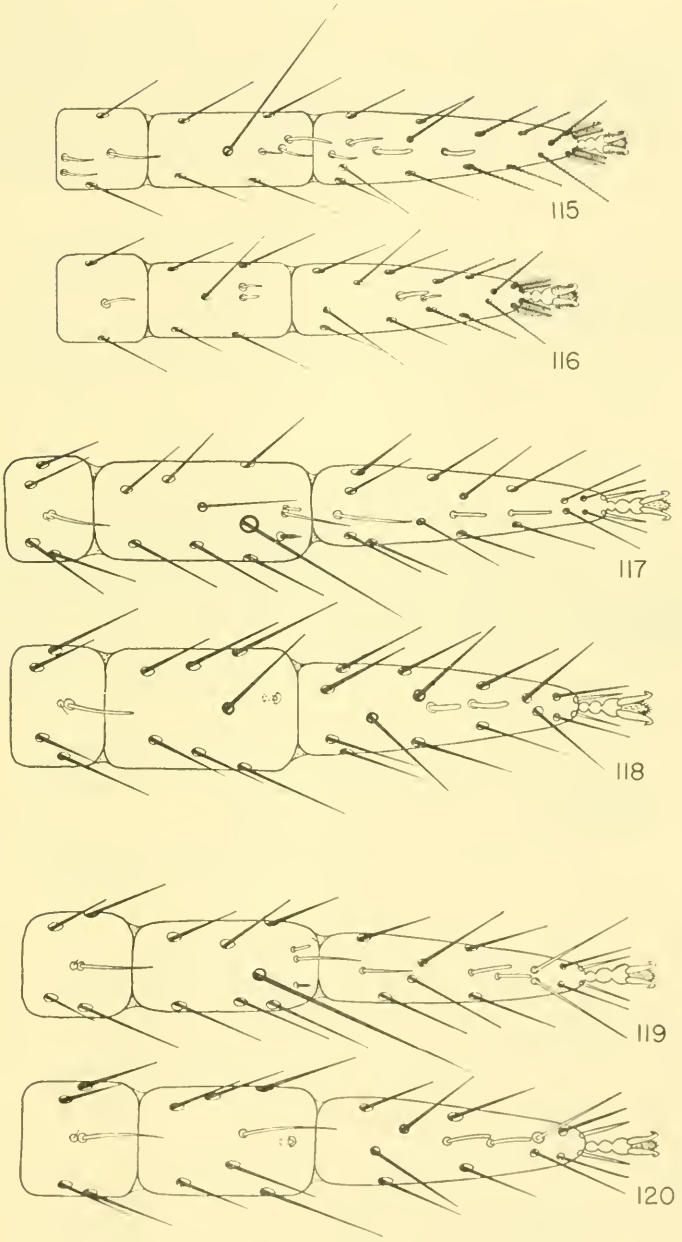


FIGURES 115-120

Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)
(Figs 115, 116, scale A; figs. 117-120, scale B)

Figs. 115, 116. *Cyta coerulipes*
Figs. 117, 118. *Spinibdella bifurcata*, holotype
Figs. 119, 120. *Spinibdella depressa*

Figures 115-120

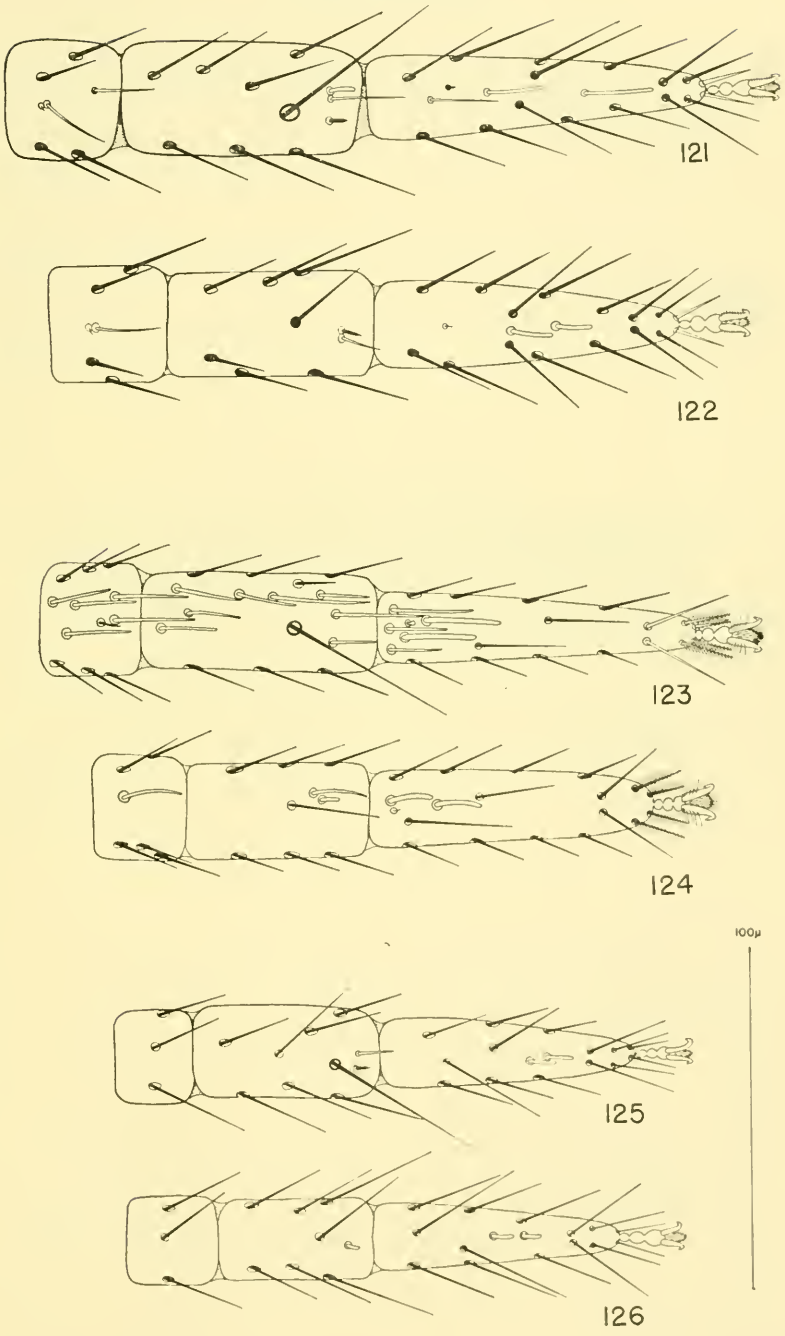


FIGURES 121-126

Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)

Figs. 121, 122. *Spinibdella ornata,* holotype
Figs. 123, 124. *Spinibdella tenuirostris,* type
Figs. 125, 126. *Spinibdella cronini*

Figures 121-126

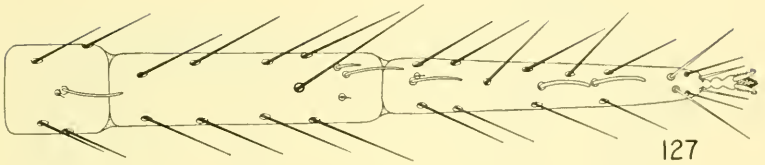


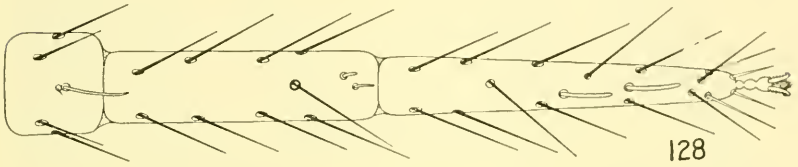
FIGURES 127-132

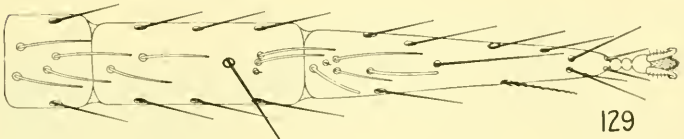
Dorsal aspects of the three distal segments of legs I and II
(Legs I, odd numbers; legs II, even numbers)
(Figs. 129-130, scale A; figs. 127-128, 131-132, scale B)

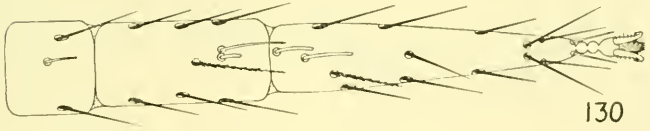
Figs. 127, 128. *Spinibdella corticis*
Figs. 129, 130. *Biscirus silvaticus*
Figs. 131, 132. *Monotrichobdella maxosburni*, type (tritonymph)

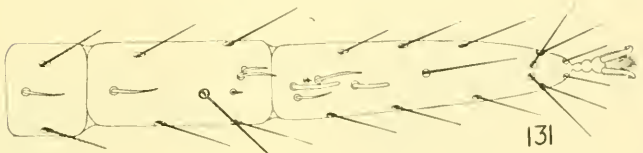
Figures 127-132

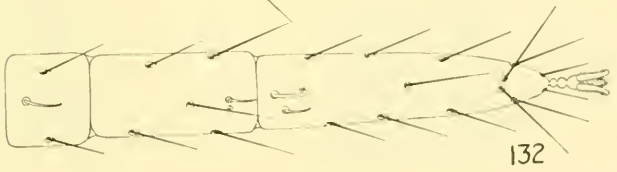












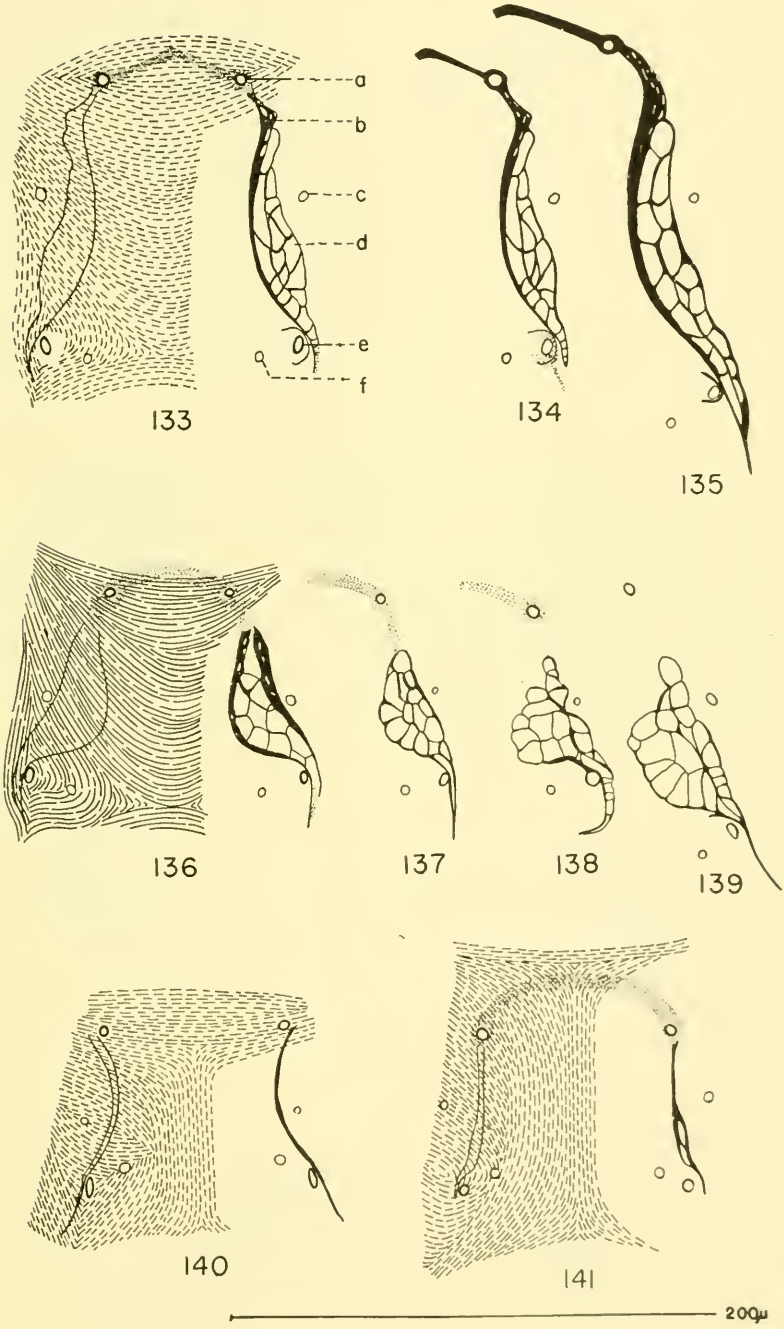
FIGURES 133-141

Striation patterns on the dorsum of the propodosoma

Fig. 133. *Bdella longicornis* from Cortez Pass, Mexico
- a. anterior pseudostigmatic organ
- b. lateral internal apodeme
- c. insertion of the lateral propodosomal seta
- d. minor internal apodemes
- e. posterior pseudostigmatic organ
- f. insertion of the median propodosomal seta

Fig. 134. *Bdella longicornis* from Cortez Pass, Mexico
Fig. 135. *Bdella longicornis* from Cortez Pass, Mexico
Fig. 136. *Bdella muscorum* from Douglas Lake, Michigan
Fig. 137. *Bdella muscorum* from N. W. Arkansas
Fig. 138. *Bdella muscorum* from Douglas Lake, Michigan
Fig. 139. *Bdella muscorum* from Iceland
Fig. 140. *Bdella tropica,* holotype
Fig. 141. *Bdella distincta,* lectotype

Figures 133-141

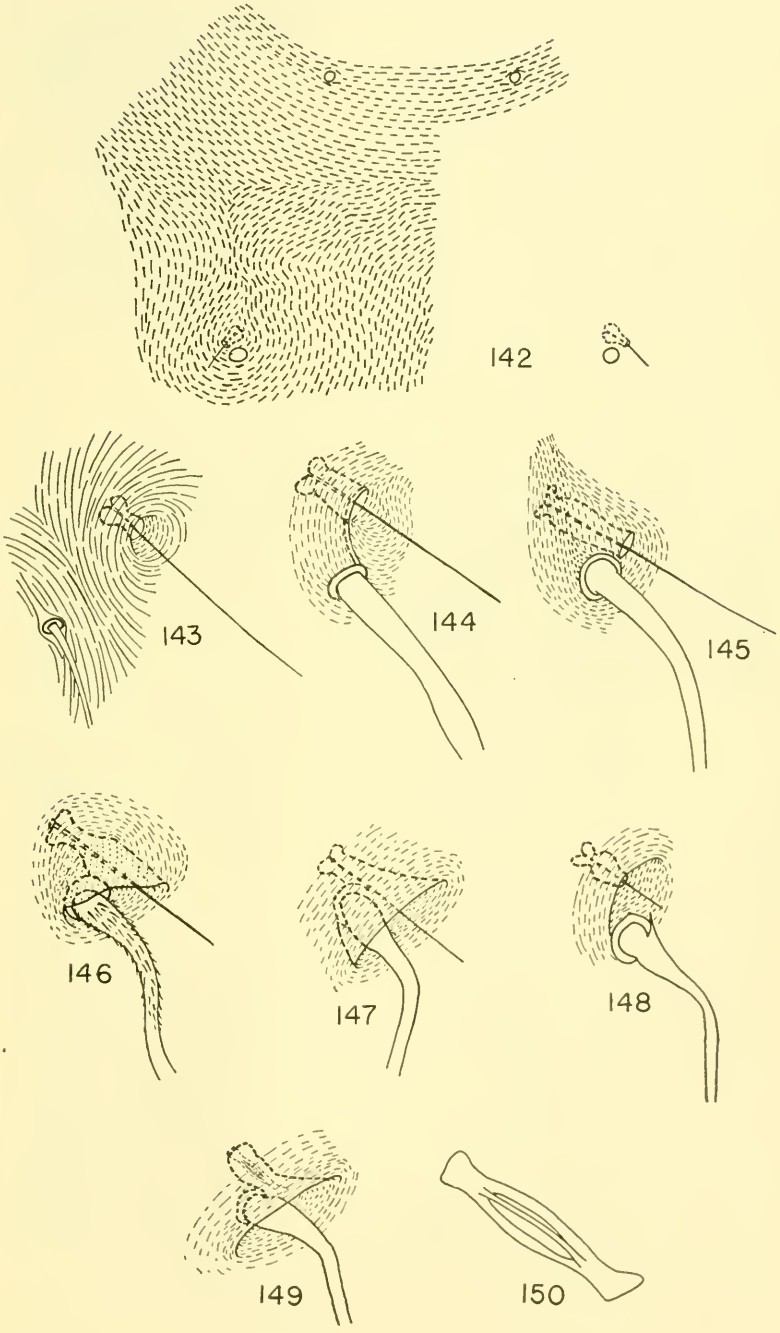


Figures 142-150

Modifications of the posterior sensilla and median propodosomal setae of *Thoribdella* species

Fig. 142. General striation pattern of *Thoribdella* species
Fig. 143. *Thoribdella spinosa,* holotype
Fig. 144. *Thoribdella californica*
Fig. 145. *Thoribdella meridionalis*
Fig. 146. *Thoribdella communis,* holotype
Fig. 147. *Thoribdella simplex,* holotype
Fig. 148. *Thoribdella insolita,* holotype
Fig. 149. *Thoribdella truncata,* holotype
Fig. 150. *Thoribdella truncata,* enlargement of posterior sensillum

Figures 142-150

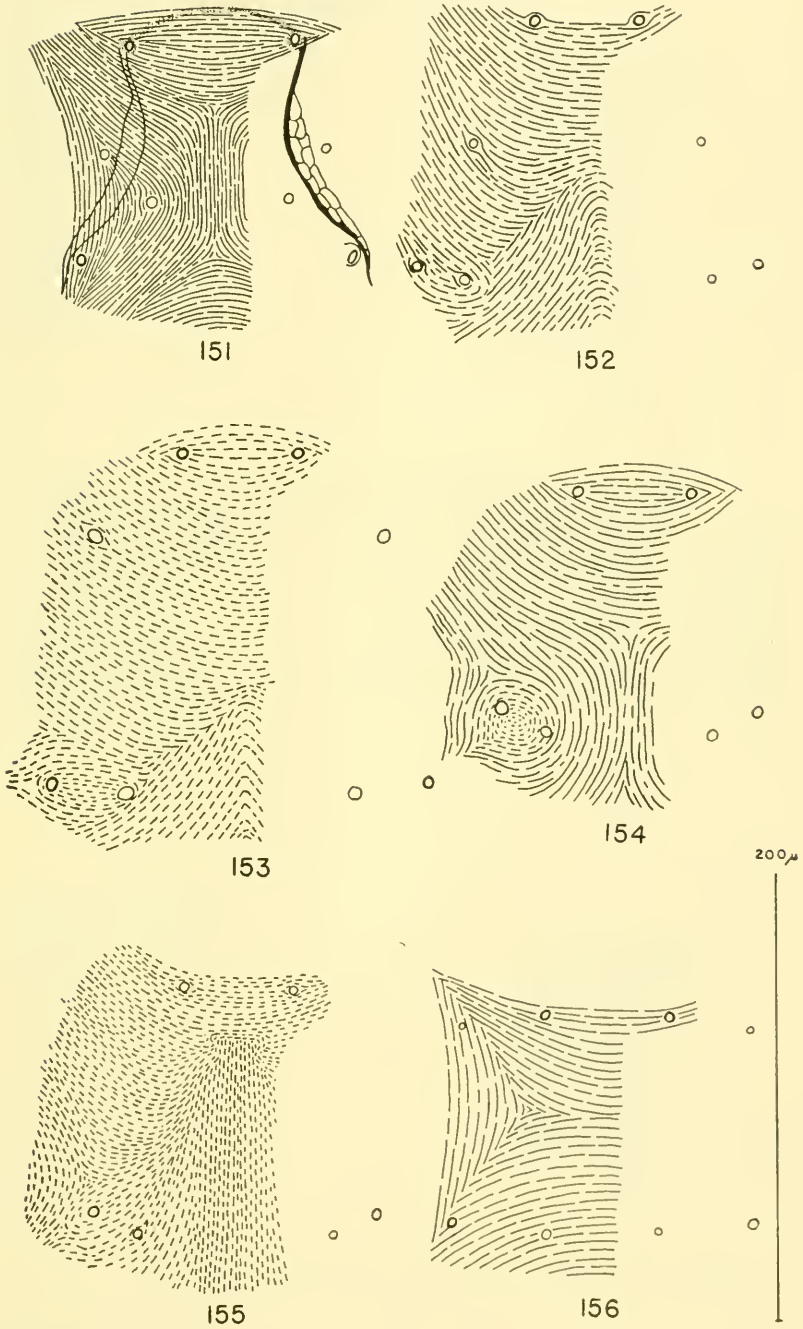


FIGURES 151-156

Striation patterns on the dorsum of the propodosoma

Fig. 151. *Bdella longistriata,* holotype
Fig. 152. *Octobdellodes hurdi,* holotype
Fig. 153. *Octobdellodes infrequens,* holotype
Fig. 154. *Odontoscirus iota,* holotype
Fig. 155. *Bdellodes bisetosa,* holotype
Fig. 156. *Spinibdella corticis*

Figures 151-156

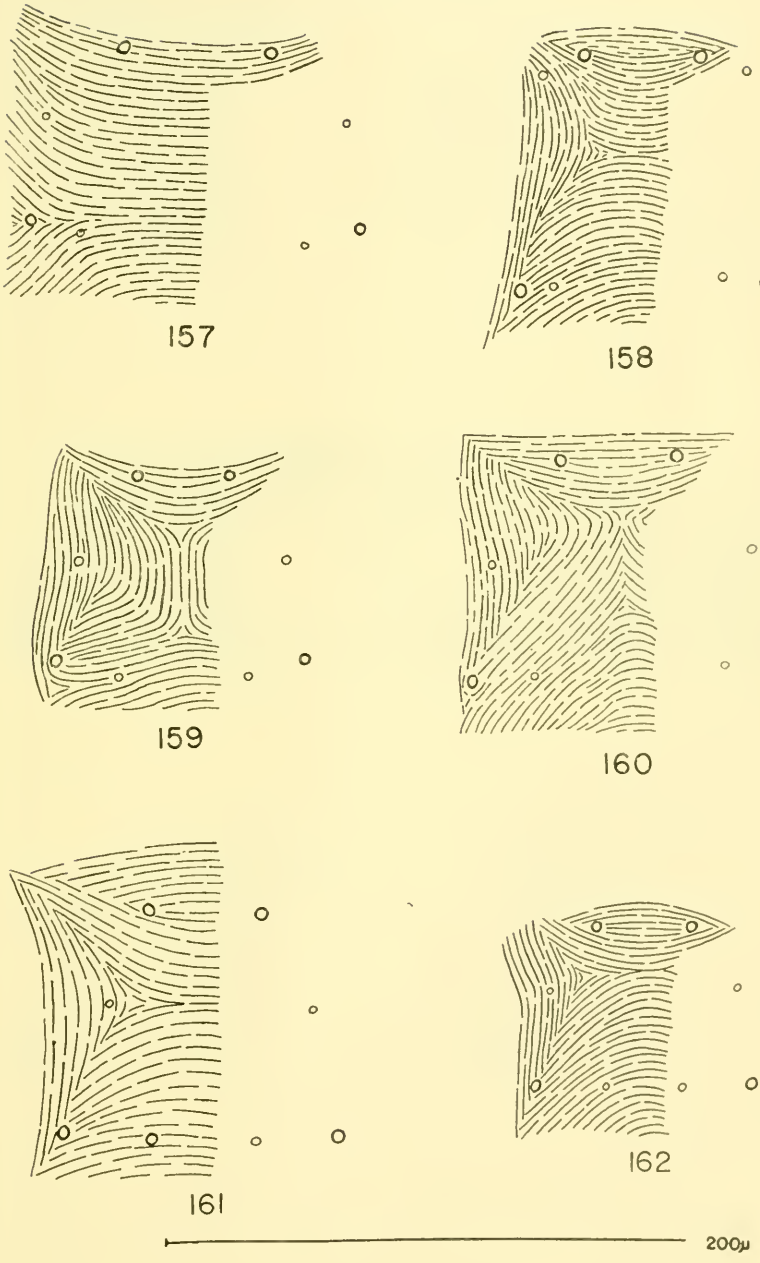


FIGURES 157-162

Striation patterns on the dorsum of the propodosoma

Fig. 157. *Spinibdella tenuirostris,* type
Fig. 158. *Spinibdella depressa*
Fig. 159. *Spinibdella cronini* from Mexico
Fig. 160. *Spinibdella cronini* from Utah
Fig. 161. *Spinibdella ornata,* holotype
Fig. 162. *Spinibdella bifurcata,* holotype

Figures 157-162



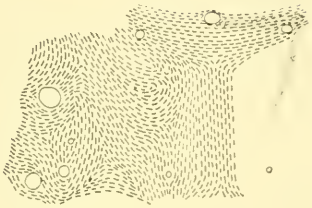
FIGURES 163-168

Striation patterns on the dorsum of the propodosoma

Fig. 163. *Neomolgus mutabilis,* holotype
Fig. 164. *Cyta latirostris*
Fig. 165. *Cyta coerulipes*
Fig. 166. *Biscirus silvaticus*
Fig. 167. *Cyta spuria,* holotype
Fig. 168. *Monotrichobdella maxosburni,* type (tritonymph)

Figures 163-168

163



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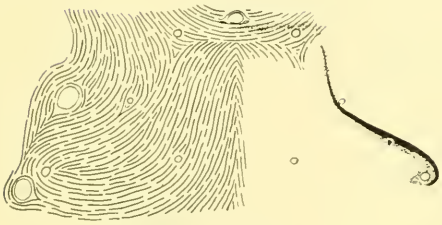

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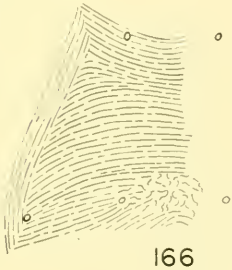

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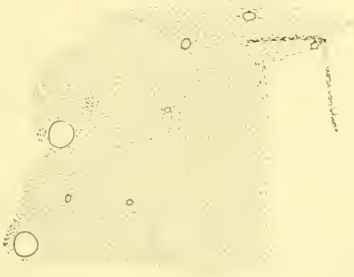

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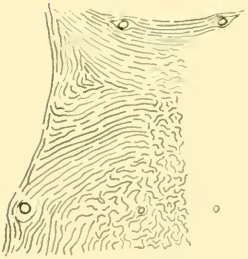

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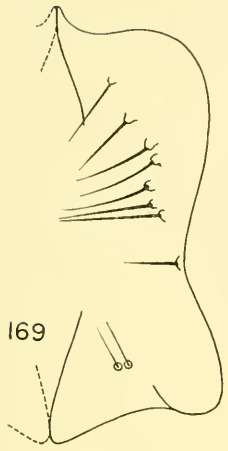
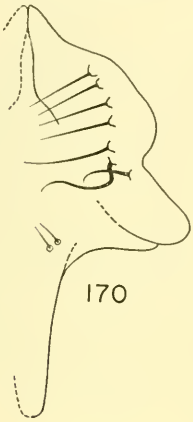
Figures 169-177

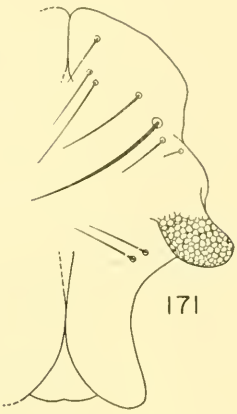
Dorsal aspects of the right amphioid sclerites

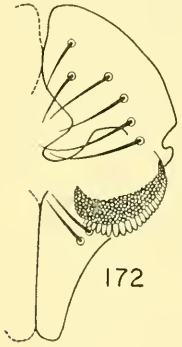
Fig. 169. *Bdella longicornis*
Fig. 170. *Bdella longistriata,* holotype
Fig. 171. *Cyta coerulipes*
Fig. 172. *Cyta latirostris*
Fig. 173. *Cyta spuria,* holotype
Fig. 174. *Spinibdella bifurcata,* holotype
Fig. 175. *Spinibdella depressa*
Fig. 176. *Spinibdella ornata,* holotype
Fig. 177. *Biscirus silvaticus*

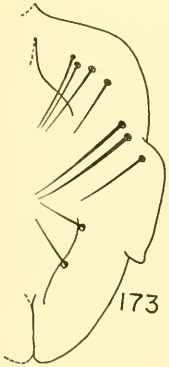
Figures 169-177











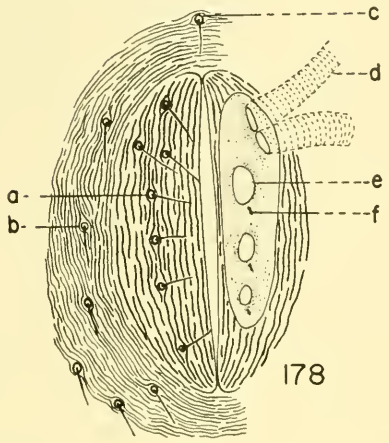
FIGURES 178-197

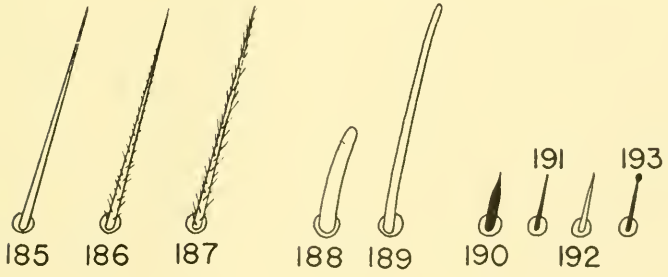
Fig. 178. Genital region of *Cyta latirostris*
- a. genital seta
- b. paragenital seta
- c. unpaired median paragenital seta
- d. genital trachea
- e. genital disc
- f. genital spine

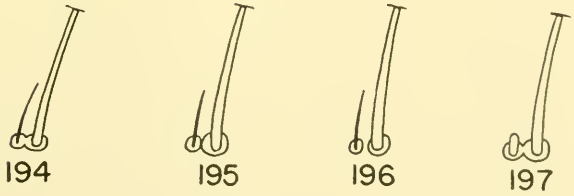
Types of setae found in the Bdellidae

Fig. 179. Tactile seta, solid, pilose
Fig. 180. Tactile seta, solid, coarsely pilose
Fig. 181. Tactile seta, solid, branched
Fig. 182. Tactile seta, solid, branched distally
Fig. 183. Tactile seta, solid, plumose
Fig. 184. Trichoboth (long sensory seta of the legs)
Fig. 185. Dorsoterminal seta of legs, hollow, nude
Fig. 186. Dorsoterminal seta of legs, hollow, minutely pilose
Fig. 187. Dorsoterminal seta of legs, hollow, pilose
Fig. 188. (Chemo)sensory seta, blunt
Fig. 189. (Chemo)sensory seta, attenuate
Figs. 190-193. Modifications of peglike setae
Fig. 194. Duplex seta, insertions contiguous
Fig. 195. Duplex seta, insertions approximate
Fig. 196. Duplex seta, insertions separate
Fig. 197. Duplex seta with microseta modified as a hollow peg

Figures 178-197







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